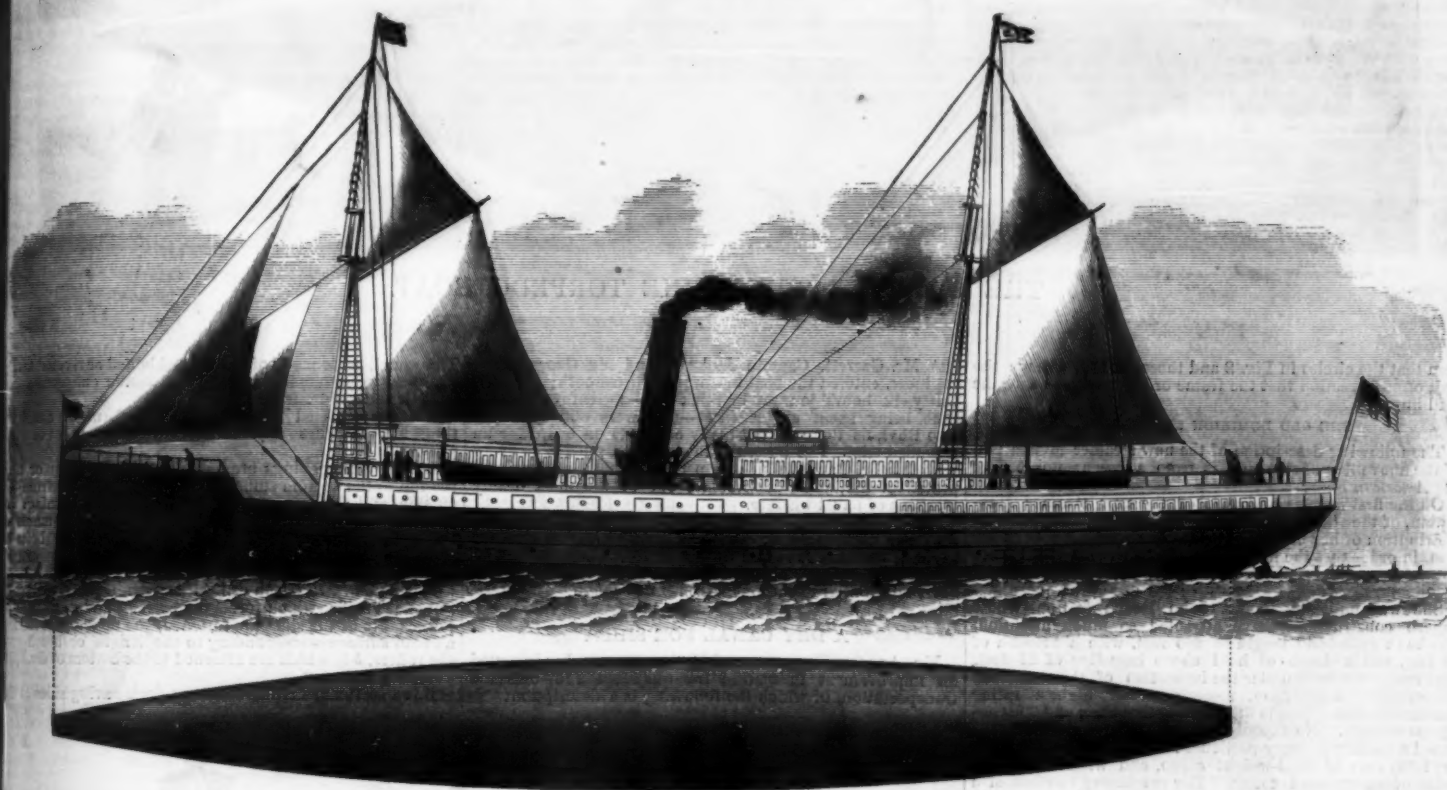## THE CYLINDROID.

By John W. Griffiths, New York.

This symbol of buoyant economy in the navigable world, when clearly understood, will very generally be adopted for distributing the buoyancy on the immersed part of flotative bodies.

We find that nature furnishes in water the basis of utility for giving form to that part of the fabric between the base and load lines of flotation, when best adapted to navigate the ocean. The law of equilibrium which causes water, when in drops, to take the spherical form, points to the circle, the cylinder, and cylindroid. We therefore infer that ship building, scientifically considered, is *practical*

geometry, and that the cylindroid is *nature's trade mark of adaptation* to the element to be navigated.

In distributing buoyancy systematically, the cylindroid is not arbitrary, either in regard to the principal dimensions or to the bulk of displacement. As soon as the length at load line, the draught of water, displacement, and coefficient have been resolved upon, the cylindroid may be projected and

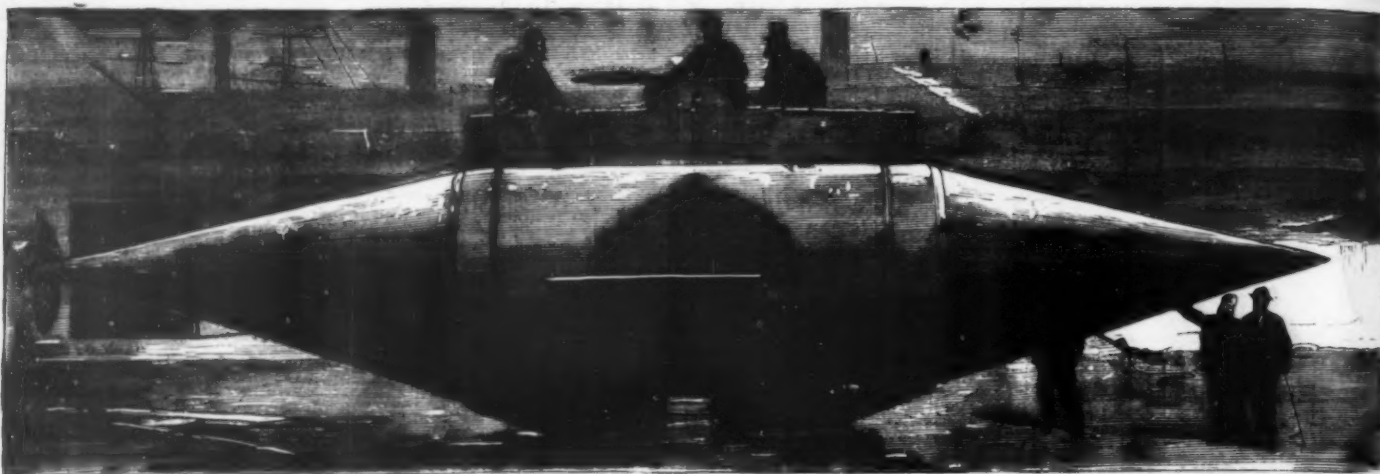THE NEW STEAMSHIP MANHATTAN.
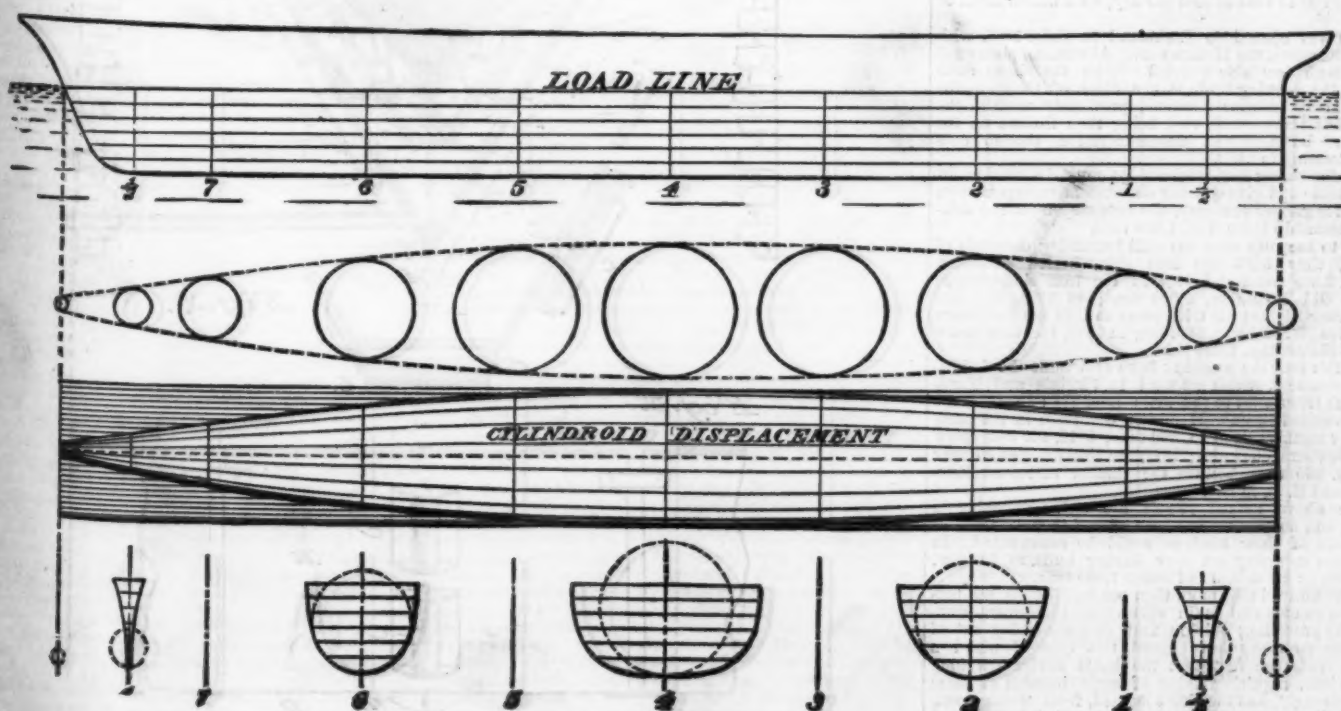
THE CYLINDROID.

applied, for harmonizing the inequalities of the design. In the accompanying illustration the same letters represent like parts in Figs. 1, 2, 3, and 4. The vertical lines numbered ½, 1, 2, 3, 4, 5, 6, 7½, are ordinates and ½ ordinates, the spaces being equal, as also the horizontal in Figs. 1 and 4 between load and base lines. Fig. 2 represents a plane cutting the cylindroid through its longitudinal center, with cross sectional areas represented by circles at each ordinate. Fig. 3 represents the parallelopipedon, *a*, *a*, *a*, *a*, within which the cylindroid, *b*, is contained, represented numerically by the decimal or coefficient of displacement distribution within the rectangular box. Fig. 4 exhibits both the circular area of ordinates and the frame section area, both containing the same area of square feet. Thus it will be

THE GARRETT SUBMARINE TORPEDO BOAT.

THIS is a new torpedo boat, invented by the Rev. G. W. Garrett, England, and besides being capable of being used as a most formidable weapon afloat, has the power of sinking and remaining under water for very many hours, and thus can enter any blockaded port unperceived. No compressed air is carried, but the air in the boat is maintained at its normal composition by a chemical apparatus invented by Mr. Garrett. When under water, also, no smoke nor gas is given off, although an engine of considerable power is kept in motion. Various experiments with the vessel have been made in the Great Float, Birkenhead, before setting off on a voyage to Portsmouth. In December

sonry, concrete, or similar substance, as shown at Fig. 1.

Figure 1 is an end view of a metal canal or way, showing the movable docks with vessel in order of transit. Fig. 2 is a cross sectional end view of the bottom of movable skating dock with the rollers attached. Fig. 3 is a side view of skating dock, showing the rollers or manner of attaching and the connections of sectional parts forming the dock.

Similar letters of reference indicate corresponding parts in all the figures.

In the drawings, A represents the sides and bottom of the metal canal or way, which is constructed of iron or steel plates with sides at an angle of about forty-five degrees from the horizon, laid and bedded on layers of rubber, *a a*, or other similar substance, inserted and resting on solid ma-

THE GARRETT SUBMARINE TORPEDO BOAT.

seen that the circles in Fig. 2 and those in Fig. 4 have the area of cross section that the frame ordinates have below the load line.

THE OLD DOMINION STEAMSHIPS.

The following description of the new steamer Manhattan, of the above line of steamers, is from a recent number of the *American Ship*:

On the first page is a picture of the new steamer Manhattan, of the Old Dominion line, together with a cylindroid distribution of her buoyancy below her load line of flotation, in order that the novice and the expert may both have an understanding of the merits of this noble specimen of architecture.

She was built by Messrs. John Roach & Son, whose superb constructions have attracted so much attention. She has a cylindroid length of 225 feet, with a breadth of 35 feet, and a depth of hold above base line of 22 feet. The vessel was built under the inspection of the American Shipmasters' Association, receiving their highest rating characterization. She is fitted for 40 first-class and 30 steerage passengers. No expense has been spared to make the vessel complete in every particular. She has a displacement for 1,200 tons of dead-weight cargo, and will carry 3,000 bales of compressed cotton. Her machinery consists of a compound engine, high pressure cylinder, 28 inches in diameter; low pressure cylinder, 53 inches, and four feet stroke; two tubular boilers; and, in addition to all the usual appliances for pumping the ship and extinguishing fires, etc., she has two independent siphon pumps, capable of throwing seven tons of water per minute.

Her performance has been satisfactory in the highest degree. She will easily average 12 miles per hour, with a consumption of 15 tons of coal per day, on a line draught of 15 feet.

The line was opened to Richmond in July, 1865, with two small steamers, the Hatteras and Albemarle, about 900 tons each, both new side-wheeled. With the sharp competition in the carrying trade at the close of the war—the result of many inferior steamers, previously used in the United States transport service, being then thrown on the market—the business was unremunerative, though constantly increasing in bulk.

In 1868, foreseeing that larger ships must be used to develop the trade and give quicker dispatch in transportation, as well as for greater economy, the company built the side-wheeled steamship Isaac Bell, 1,600 tons.

In 1870, to keep up with the still increasing demands of the trade, they built the iron side-wheeled steamship Wyanoke, 2,000 tons; and in 1872 the iron side-wheeled steamship Old Dominion, 2,200 tons; in 1873, the iron screw steamer Richmond, 1,400 tons; in 1874 the iron screw steamer Geo. W. Elder, 1,600 tons; in 1879, the iron screw steamship Manhattan, 1,600 tons.

During this time the company have also built the following small steamers, which are used in Virginia and North Carolina, as tributaries to the main line, viz.: In 1874, the iron side-wheeled steamer Hampton, 600 tons; in the same year, screw steamer Pamlico, 350 tons; 1876, the iron screw steamer Newberne, 600 tons; 1877, the side-wheeled steamer Accomack, 350 tons, besides the smaller screw steamers Widgeon and R. L. Myers.

All the above named vessels are unexceptionable in character, and no expense has been spared to make them as good vessels of their kind as could be constructed. In addition, the company are now having built, at Chester, another iron screw steamer of about 1,000 tons.

It will be noticed that more than one-half of all the tonnage above enumerated is in side-wheeled steamers—contrary to the prevailing opinion that they are going out of date. The company have found this type of wheel a necessity, from the fact that the boats navigate a long crooked river, requiring ships of great breadth of beam and light draught, and they have learned, from actual experience, that they are much more easily handled under these circumstances than screw steamers. The record to-day of the steamship Old Dominion compares favorably, both for speed and economy, with the best screw steamers out of New York.

last Mr. Garrett, Captain Jackson, and Mr. George Rice, engineer, entered the boat to start for Portsmouth; but after thirty-six hours' journey in thick fog—a great part of the time being spent under water—they were obliged to put into Rhyl, as there are not many comforts on board for an extended trip. The boat, the inventor tells us, is in every way a success, and will easily perform what has been expected of her, and thus becomes one of the most deadly weapons of naval warfare.

Mr. Garrett has also constructed a diving dress, which enables a diver to dispense with all communication with the surface; and has invented an apparatus, which he calls a pneumatophore, the object of which is to enable men to enter mines after explosions.—*London Graphic.*

A DRY CANAL FOR SHIPS.

MR. ADOLPH TOELLNER, of Moline, Illinois, has invented an improvement in marine transshipment and overland transportation, of which the following is a description.

This canal, A, is made of plate metal bolted or riveted firmly together, so as to make and present inside one continuous smooth and solid surface.

It is not confined to this particular form of construction, but includes any form of bed or way on this principle.

At intervals openings are made at the sides from or near the top to the bottom sufficient to admit a person from the outside, and also serve for drainage. These openings are protected by steel bars of such strength that the firmness of the surface may not be impaired, and fastened by bolts or rivets, so as to present no obstacle to the evenness of the surface.

D is an elevated bench or keel, in form similar to the T rail of railroads, which forms the bottom, and to which the lower parts of the sides are fastened, the upper part having a broad surface corresponding to the length or bearing of the rollers, *b b*, which are attached to the bottom of dock, B, as shown in Fig. 2.

B is a sectional skating or rolling dock having sides at the
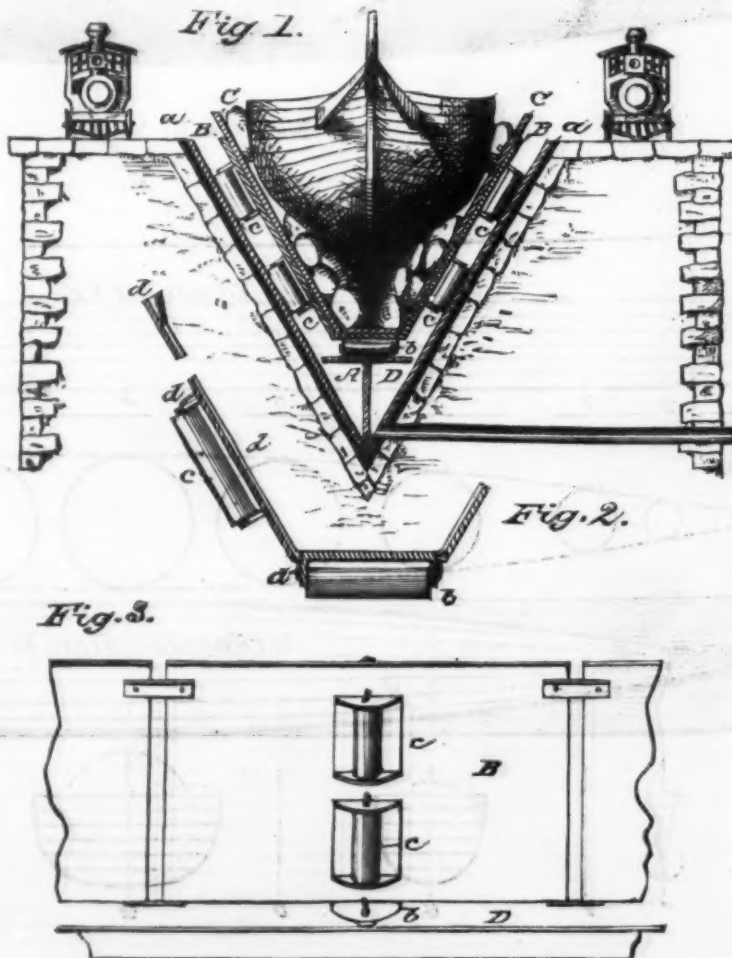
A DRY CANAL FOR SHIPS.

same angle as the way, A, and made and shaped to conform to the inside of canal, A. It is made of steel plate in section of three or more, and connected together in a hinge-like manner by means of loose rings or slotted steel bars, or in any like manner, so that it will conform to curvatures that may be in the course of the canal or way, A. Along the bottom of dock, B, are placed steel rollers, *b b b*, entire bottom as may be desired, shouldered, and fitted into metal spaced as may be desired, shouldered, and fitted into metal frames which are firmly attached to the bottom of B, so as to have even and equal bearing throughout on keel, D. *c c c* are steel rollers like *b b b*, not necessarily as large, but fitted in metal frames, and firmly attached to the sides in a vertical or upright position, and made to have equal bearing on the entire inner surface of A. These rollers serve the same purpose as wheels. Wheels and rails might be used, if thought desirable, in place of the rollers and the even surface of the canal.

d d are stationary oil cups having metal or rubber tubes or pipes running to each journal of the rollers, thereby keeping up a constant supply of fresh oil. C is the inner dock or shoe, being the part for receiving the vessel. It is constructed to conform to B, in shape made of one unbroken surface at sides and bottom, but open, like dock, B, fore and aft. It is made to work inside of dock, B, and is connected by pivot, or in such manner that it will retain its even position when B may be on a curve.

In constructing in this manner and form, the hull of a vessel, when entered into the dock or shoe, finds an even and secure rest on the sides if it happens to be too broad to set on its keel; and in case a vessel is narrower than the dock it would rest on an even keel, and could in either case be more easily and effectively kept in and secured in an upright position than could be done under any other form of receiving dock.

The manner of lifting a vessel from the water and getting it into position for a trip overland is to build an inclined way whatever distance may be necessary down into the harbor to whatever depth required. At the head of the incline is placed stationary power with the necessary machinery to operate with. The docks, B and C, being let down on the incline, B, into the water far enough to allow the vessel to be floated into the dock or shoe, C, to the desired position, it is made fast and held in its upright position by means of rubber air bags or balls, or in any manner desired. After being brought to the top of the incline the whole is moved forward on the railway to the desired point.

In constructing the canal bed sufficient space is to be left on either side of the way to lay two or more lines of railroad track to be used for propelling power.

THE GREAT BRIDGE OVER THE FRITH OF FORTH IN SCOTLAND.

THE railway suspension bridge over the Forth at Queensferry will be, when completed, the most remarkable application of the suspension principle in the world. The plans of the engineer were approved by the Board of Trade some time ago; and as the contracts for the work have now been formally completed, the time seems opportune for giving some account of this great engineering undertaking. The only alteration required by the Board of Trade on the plans as submitted to them related to the height of the central span above the waterway of the Forth. As originally drawn, the plans allowed for a height of 150 feet above high water mark, the object being to allow of the free passage of ships of war to the anchorage of St. Margaret's Hope, above North Queensferry. Taking into account the recent changes in naval architecture, it occurred to the Forth Bridge Railway Company that a height of 135 feet would more than meet practical requirements, while it would materially reduce the expense of the undertaking. The Board of Trade held a special inquiry in Edinburgh on this point, and, after hearing counsel for the various interests involved, including Grangemouth, Alloa, and other river ports, it was resolved to insist on the original plan being adhered to.

The breadth of the Forth at Queensferry is rather more than a mile, but as the viaduct is to be continued overland on the north shore for several hundred yards, the whole length of the bridge will be about one mile and one-third. This, however, gives no fair idea of the breadth of span to which the physical conditions require the suspension principle to be applied. In the midst of the firth, but rather nearer to the northern than to the southern shore, rises the rocky islet of Inchgarvie. On either side of this island the bed of the river sinks to a depth which is impracticable for engineering purposes. On the north side the bed sinks to a depth of 210 feet, on the south side to 180 feet, below the water mark; and it is there, for a breadth of 1,600 feet on either side, that no practicable bottom can be found for piers, and, therefore, that the suspension principle has perforce to be resorted to. Between the deep furrow on the south side of Inchgarvie and the southern shore there is a reach of comparatively shallow water, with a maximum depth of 30 feet, but within which foundations may be found for some 12 or 15 piers. Viewed in profile from the bosom of the firth, the bridge will thus present to view five distinct sections. First, there is a shallow water section on the south side, covering some 2,000 feet, and supported on 16 piers; then there is the deep water section, south of Inchgarvie, traversed by a suspension bridge; next there is the Island of Inchgarvie itself, over which the viaduct will be carried on two or three piers; then there is the deep water section north of Inchgarvie, spanned by a second suspension bridge; and, lastly, there is the northern shoreward section, which carries the viaduct on 10 or 11 piers from the brink of the tide to the dead level of the Fife shore. The great features of the architectural design, as seen from the firth, will be the four pairs of lofty towers on which the massive steel chains which are to support the two suspension bridges will be hung, and the two pairs of landward buttresses to which the suspending chains will be anchored. Of the towers, two pairs will rise from the Island of Inchgarvie, and will reach the imposing height of 596 feet. Two pairs on the shore of North Queensferry, and other two on the brink of deep water on the southern channel, will attain to a height of 584 feet. The two pairs of buttresses on the north and the south side respectively will be, of course, less lofty; but they will be bold and striking masses of masonry. No one can compare the engineer's plans with the physical aspect of the scene of his projected operations without being impressed by the combined boldness and ingenuity of his design.

A bird's-eye view of the plan serves only to enhance its merits and to increase one's wonder. Those parts of the bridge, north and south, which rest on piers with a solid foundation, will consist of a single permanent way 25 feet broad, and carrying a double set of rails. But the intervening portions carried by the suspension bridges will consist of two distinct and parallel branches, each 15 feet broad, each carrying a single line of rails, and 100 feet apart. These branches will be tightly braced together; and this arrangement has been adopted in order to give greater breadth, and therefore greater stability to the whole structure. Seen from above, the outline of the design has the appearance of a shuttle with elongated points. The divergence of the branches begins at the massive piers, two on each side, to which the suspension chains will be anchored, and the maximum of divergence, 100 feet, will be attained before the lofty towers are reached. While the bridge throughout the greater part of its extent makes necessarily a straight course, the shoreward part at either end forms a gentle curve.

From each shore to the beginning of the suspension bridge the line rises with a gradient of 1 in 100. In the shoreward sections, and in that over Inchgarvie, the permanent way rests on the upper members of the lattice girders; but in the two suspension sections it rests on the lower members. By this contrivance here, as in the case of the Tay bridge, the full height of 150 feet above the high water mark is confined to the central sections only.

It will be evident from what has been said that each of the deep water channels north and south of the Island of Inchgarvie will be spanned by a double suspension bridge. Each of these double bridges will consist of four parallel and enormous lattice girders—two for each branch. These girders will be 1,600 feet long. Seen in profile, their upper members will form an arched outline, with a maximum height of 50 feet and a minimum of 19 feet besides the towers. On these towers, of course, their ends will rest; but they will derive their main support from four immense steel chains, one for each girder, which will be slung over the towers and fastened to the anchoring piers at either end. The girders will be attached to the chains by stout wrought iron rods at intervals of 50 feet.

Vast as the undertaking seems, there is every reason to have confidence in its practicability. The engineer is Sir Thomas Bouch, C.E., whose greatest achievement hitherto—the Tay bridge—has turned out a splendid success—a success recognized and indorsed in the honor of knighthood awarded to him since its completion. The great expense of the scheme is a formidable obstacle to its accomplishment. The capital of the Forth Bridge Railway Company is £1,-250,000. The interest on this sum—£75,000 a year—has been guaranteed by four railway companies, the largest share being borne by the North British, which will be saved by the new route an annual outlay of £40,000 on account of its ferry traffic between Granton and Burntisland. The other guaranteeing companies are the Midland, the North-eastern, and the Great Northern. The contractors selected are Messrs. W. Arrol & Co., Dalmarnock Iron Works, Glasgow, who will execute the whole of the works, both in brick and in iron, with the exception of the steel chains, which will be supplied by Messrs. Vickers & Son, Sheffield. The estimated cost of the entire undertaking is £1,116,000, which is equivalent to the whole capital of the company, less £134,-000 set aside as guaranteed shares by the North British Company under the Fife Railways Act of 1876. A formal commencement of the work of construction was made in September last, when the foundation was laid of one of the great towers on the Island of Inchgarvie. When the masonry of that tower had been carried up to high water mark, the work was suspended in anticipation of the contract for the whole undertaking being accepted and entered on. The expectation was that the bridge could not be finished within less time than six or seven years; but it is stated that it is an express stipulation with the contractors that the completed fabric is to be handed over to the company not later than Jan. 1, 1885.

Of the boldness of the conception of the plan or of the grandeur of the work when finished there can be no doubt. There can be as little reason to question the immense public convenience which it will afford. The change can hardly fail to result in a very great increase in the direct railway traffic by the east coast of Scotland. Dundee, Arbroath, Montrose, and Aberdeen will thus be brought into immediate connection, not only with Edinburgh and Leith, but also with the traffic of the east coast of England and the Midland system. In this view, the North British, the Great Northern, the North-eastern, and the Midland Railway Companies are but looking after their own interests in encouraging the Forth bridge scheme. It cannot be doubted, at the same time, that the gains in some quarters will be counterbalanced by losses in other directions. From Granton and Burntisland, for example, much of their present glory must needs depart, and the traffic on the south coast of Fife will beco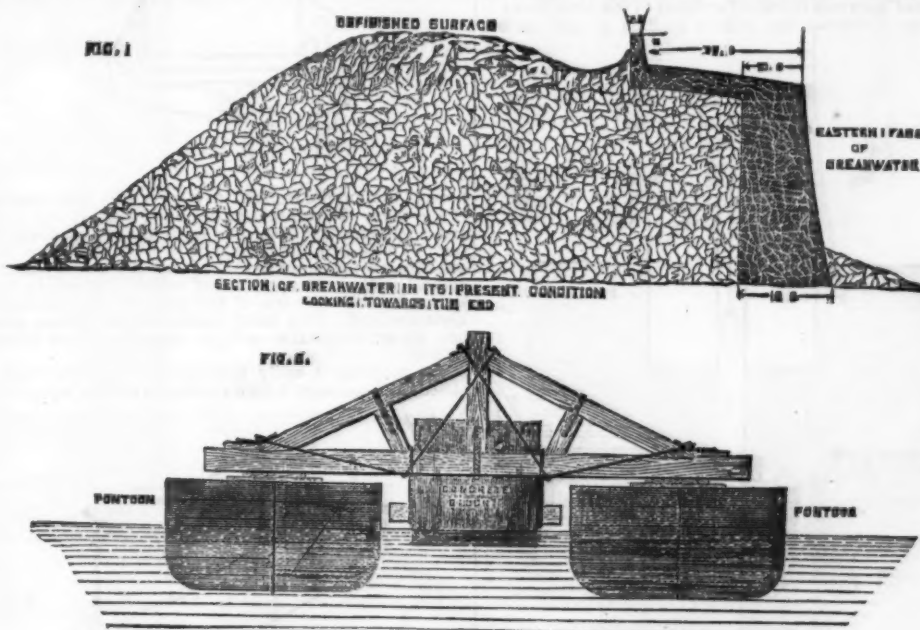me purely local and subsidiary. But the country as a whole will gain by the change, and in railway, as in other speculations, regard must be had to "the greatest good of the greatest number."—*London Times.*

THE TEES BREAKWATER.

THE Tees Conservancy Commissioners have a custom worthy of imitation by all similar bodies. Once a year they invite their leading constituents, including engineers, shippers, shipowners, shipbuilders, manufacturers, riparian owners, and others, to accompany them on a visit to their engineering works in progress. A similar excursion took place in September last, in one of the steamboats belonging to the commissioners. The approach of the completion of the South Gare Breakwater, after having been sixteen years in progress, made the visit specially interesting.

This breakwater, which is destined to form the southern boundary of the mouth of the Tees, is expected to be finished next summer. The remaining portion, however, is the most difficult part of the work. The material employed is mainly slag from the blast furnaces of the district. The total length will be about 2½ miles. For the first 1½ miles the mere tipping of the slag was sufficient; but so soon as the end of the tip reached comparatively deep water, every storm that came broke down and washed away the end portion. After persevering for some time with this simple mode of construction, only to meet repeated failure, the engineer, Mr. John Fowler, M.I.C.E., was forced to adopt another method. He constructed along the outer or seaward face of the breakwater a huge concrete wall, which was made to advance concurrently with the other part of the work, consisting simply of slag, and serving as a backing for the concrete wall. This latter is 18 feet thick at the bottom, tapering up to 10 feet at the top—see sketch A.

The breakwater having nearly reached to the point where the circular head is to be situated, that portion of the structure has been independently commenced. An enormous concrete block, 16 feet cube, and weighing about 250 tons, has been placed in position. Another block has been made and is to be transferred to its final resting place. Some six or eight more will be added, and then others of smaller dimensions, to fill in between the larger blocks, so as to form what may be called the "toe" or lower extremity of the

FIG. 1

UNFINISHED SURFACE

EASTERN FACE OF BREAKWATER

SECTION OF BREAKWATER IN ITS PRESENT CONDITION LOOKING TOWARDS THE END

FIG. 2.

PONTOON PONTOON

THE TEES BREAKWATER.

pier, where the sea may be expected to have great force. Upon a base of this character will be built the pier head, a cylindrical structure 100 yards in diameter, and surmounted round the periphery by a strong parapet. The concrete blocks are constructed in a small bay on the inner side of the breakwater. Two huge beams of wood strapped and stayed with iron, and resembling the principal rafters of a roof, are placed beside and across a block so as to form a pair, grasping the block between them. Chains are then passed round the tie beams and underneath a pair of projecting timbers left in the block and solid with it. The principals are so lashed together and to the block that a pair of pontoons can be floated under their ends. With the rising of the tide the whole fabric, including pontoons, principals, and block, are floated away and taken to the place where it is desired to lower the latter. A simultaneous cutting of the lashings at four points is sufficient for this purpose; the block drops, and the pontoons and principals, relieved of their burden, float away to their moorings—see sketch B. The concrete of which the blocks are made is composed of four parts by weight of slag, three of sand, and one of cement. The total length of concrete wall now finished is about 3,000 feet, and there remains about 200 feet more to accomplish before the pier head is reached.

So soon as the South Gare Breakwater is finished, the corresponding breakwater on the north side, and which will be called the North Gare, will be commenced. It will extend from a point called Seaton Snook in an eastward direction for one mile, where it will be also terminated in a circular head. The extremities of both piers will be furnished with lighthouses.

The width of the river mouth between the two pier heads will be 700 yards. The distance thence to Middlesbrough is about six miles. Dividing this into three portions of two miles each, the center portion will form the harbor of refuge, thus providing two miles or thereabouts of anchorage on either side of the channel, and suitable for the largest vessels. It is expected that the North Gare Breakwater will take six years to build, and will cost £150,000. Before the Tees Conservancy Commission was formed there was at times not more than three feet of water on the bar, and it is said it was occasionally possible to walk across it without danger. Each vessel entering or leaving had to steer from the fifth buoy outwards, a distance of two miles in a course

represented by the letter S. The channel of the river was, moreover, continually shifting, so that no captain returning from a voyage could be sure it would be the same on his return as when he left. The improvements in the river have now had so beneficial an effect that the lower channel is in a direct line and not liable to alter. The minimum depth of water at spring tides is now 12 feet, and at neap tides 17 feet. The maximum depth is at spring tides 30 feet, and at neap tides 25 feet. Near Middlesbrough the maximum depth, high water, is 24 feet, and the minimum, low water, 7 feet 6 inches. It is hoped eventually to increase the minimum to 14 feet at Middlesbrough, and 12 feet at Stockton.

As an instance of the general facilities now offered for quick loading it may be mentioned that a vessel recently entered the river, proceeded to Middlesbrough, took in 680 tons of cargo, returned, and was again passing over the bar on her outward voyage in ten hours. With such facilities and such prospects of their gradual increase by the wise administration of the Conservancy Commissioners, aided by the skill of their officers, and provided with adequate funds, surely the Tees is destined quickly to take rank with the Tyne and the Clyde as one of the most important navigable rivers in Europe.—*The Engineer.*

PNEUMATIC FOUNDATIONS *

By A. HEINERCHEIDT.

FOUNDATIONS for abutments or piers which are constructed by aid of compressed air generally employ a cylindrical caisson of iron, divided into two unequal parts by a horizontal partition; the upper part, which is the larger, is the caisson proper. It is a coffer dam, within which the masonry is built in the open air. The lower part, which is filled with compressed air, and within which the excavation is carried on, is called the *working chamber.* It is furnished with one or two shafts made of boiler iron, which are surmounted with an iron chamber called the air chamber. Adjoining this is the "equilibrium" chamber, or air lock, through which workmen and materials must enter. A pipe from the compressing engine furnishes the air chamber with compressed air. The air chamber and air lock are generally located above the highest level of the water, in order to insure the escape of workmen in case of accident to the dams above.

Figure 1 exhibits the relative position of the various parts.

Fig. 1.
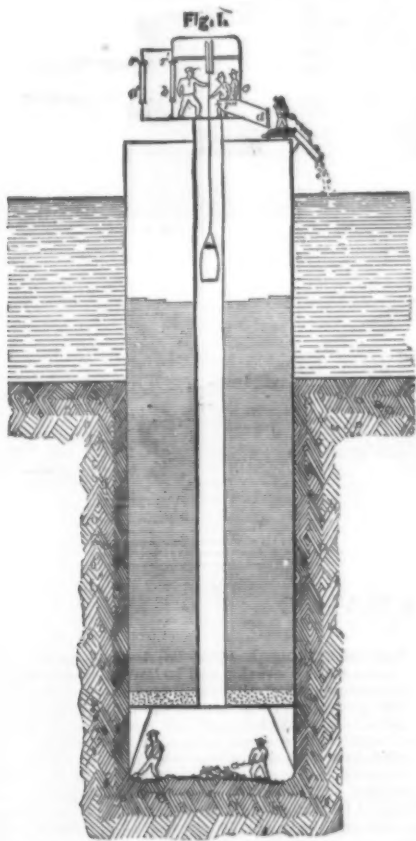
The outlets to the air chambers—the air lock and the chutes—are furnished with two ports to be opened successively. The ports, *a* and *b*, of the air lock open toward the interior, so that the air pressure tends to keep them closed. To open either of them it is necessary to equalize the pressure upon its opposite sides by means of the cocks, *r* or *r'*. There is thus no danger of the port opening suddenly.

On the other hand the *discharge lock* is furnished with a port, *d*, which of necessity opens outward. Normally the port, *c*, is open, and the chute or lock is charged from within. When it is filled, the port, *c*, is closed, and a workman on the outside in charge of the port, *d*, is notified by a convenient signal. The outer port is then opened, and the charge removed. Then follows the closing of *d* and the opening of a cock, *r''*, which puts the discharge lock in communication with the air chamber. Equilibrium being thus established between the two sides of the port, *c*, it is reopened, and the charging is again resumed.

There is a constant source of danger in this system. Suppose there is a pressure of two atmospheres in the interior; then the pressure upon the port, *d*, tending to force it open is about twenty thousand kilogrammes to each square meter. Any mistake on the part of the workman who has charge of the exterior port, whereby *d* is opened while *c* is also open would result in serious disaster to the workmen within.

In order to prevent such a catastrophe the following plan has been devised by the writer. It is designed to prevent absolutely the opening of the exterior port until the interior one is completely closed.

* "Annales des Ponts et Chaussées."

Fig. 2 represents the exterior port, *d*. It is a cast iron disk suspended at the middle upon a shaft, which latter also is made to pass through two iron ribs, which cross the disk to unite in a fork at one edge, and diverging from this point terminate on the other side of the disk in a hinge joint, working about an arbor fixed to the side of the chute. A third arbor, also attached to the chute on the opposite side,

Fig. 2.*a*
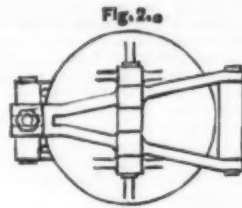
supports a rod, which passes through the forked rib, and is secured by nut and washer, as shown in Fig. 2. When this screw is tightened, an equal pressure is exerted on the entire circumference of the seat of the disk. By employing rubber, an air tight joint is secured.

Thus far the description applies to the system in general. The modifications introduced by the writer are as follows:

The fork which receives the screw rod is constructed with a sloped bearing for the washer, as shown at *e;* the washer being also made to fit its seat. This secures the port against being thrown open from any pressure from within; also against too sudden opening by ordinary means. Several

Fig. 2.*b*
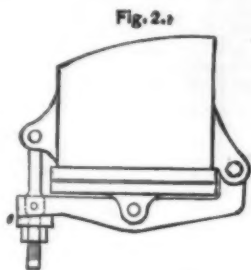
turns of the nut are required to allow a very small opening of the port. The workman, therefore, employs less force, and is relieved from some of the precautions employed before. A hole is made through both branches of the fork and through the screw rod. Through this hole is passed a vertical rod, to the upper end of which is attached a bent lever. To the other arm of the bent lever is connected a horizontal rod. This latter passes through stuffing boxes into the air chamber, so as to be controlled from within. (Fig. 3.)

The working is easily understood. When the outer is closed, it is necessary before opening it to raise the vertical

Fig. 3.
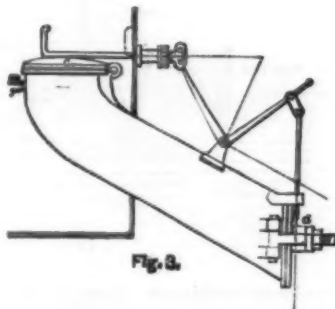
rod. This cannot be done unless the inner part is entirely closed.

This device has been lately employed upon two air locks at Boom, for sinking pneumatic foundations for a bridge over the Rupel.

Two different plans were employed by reason of the different situations of the chutes in the two locks, but the principle is the same in both. The entire apparatus is light, not cumbrous; the time of working it is only the time required to raise the hand, and the security is absolute, as the reader is probably convinced by the above explanation.

The apparatus has been in use for two months, to the entire satisfaction of employes, and especially of workmen employed within the air chamber.

TURNER'S GAS ENGINE.

AMONGST others who for years past have given careful attention to the improvement of the gas engine, is Mr. F. W. Turner, of the St. Albans Iron Works, St. Albans, who claims to be the first Englishman who brought out a working gas engine, all others being of foreign origin. In 1874, he patented an engine, which was made and worked successfully by Messrs. Otto & Langen, of Cologne, and Messrs. Crossley Bros., of Manchester. Subsequently, being convinced of the necessity for a cheap and simple engine for superseding hand labor in driving small machinery, he applied himself to its production. The result of his labors was the gas engine exhibited at the late Smithfield Club Show, and briefly noticed by us at the time. Two of these engines, of one and two man power, were constantly at work during a recent trial of gas engines at Nottingham, and we have lately been afforded an opportunity of testing the larger of these two engines, on the crank shaft of which was keyed a 12-inch pulley, provided with a strap brake attached to a Salter's balance. Making 180 revolutions a minute, the weight on the balance showed over 21 lb. This multiplied by 3 feet, the circumference of the pulley, gives 11,340 foot pounds, or one-third of a horse power, which was obtained with a consumption of about 40 cubic feet of gas per

hour, mixed with seven times its volume of atmospheric air.

The engine shown in the accompanying illustration is free from complication, and has only three working parts. One distinguishing feature is that the center line of the cylinder does not coincide with that of the shaft, the latter being about 1½ inches in the small size, and 2½ inches in the large, outside of the center line of the cylinder. This arrangement, while permitting of a long crank with its powerful leverage, gives, with the aid of a long connecting rod, a very favorable angle of thrust. In fact, the 7 inch crank has the effect, as regards the angle made, of a 4½ inch crank, which makes a difference of 200 foot pounds in the dynamic effect of the engine. Like all gas engines, this one is single acting, and the whole of the thrust is given during two-thirds of the upward stroke. This cylinder is therefore surrounded, to this height, by a water jacket, circulating pipes from which communicate, in one arrangement, with the tank forming a portion of the standard, and in the other with a cistern in another portion of the premises, the water of which is heated for any industrial or domestic purpose. The cylinder is 4½ inches in diameter, by 14 inches stroke. The piston is lubricated by siphons; and so slight is the friction that when gas and air are turned off the weight of the piston causes it to descend in the cylinder. The slide valve, which is a perforated plate, works without friction, and in equilibrium between two faces—the cylinder and a back plate bolted to it; and the water passes first round this back plate on its way to the cylinder jacket, thus preventing
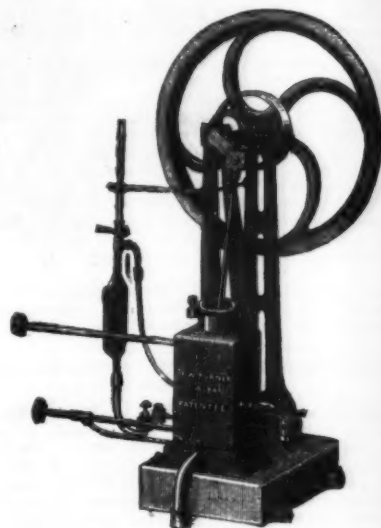

TURNER'S GAS ENGINE.

the burning of the lubricant, and also that warping of the valve which has hitherto been a difficulty in gas engines. The governor directly controls the admission of gas, more or less being admitted on the rising and falling of the spindle with its coned end fitting in to a conical seat.

The valve face is placed at the back and toward the bottom of the cylinder; it has three ports, the lowest one for exhaust, the next for the admission of the combustible gases, and the third also for admission when the second port is closed by the slide valve. The cavity in the slide valve admits the combustible gases to the cylinder, and in the interior of the slide valve is a small igniting valve, which opens internally to admit the igniting jet, but closes during the combustion of the gases. The back plate, already referred to, which has passages for the admission of air and gas, is provided with air valves working in boxes, the motion of which is regulated by cup-shaped screws. The ignition of the gases is effected by a single igniting jet placed above the back plate, on which it impinges, spreading its flame so as to cover the igniting port, which during the upward movement of the slide valve presents itself above the back plate and opposite the igniting jet. We shall watch with interest the further development of this simple and economic motor.—*Iron.*

ST. MARY'S CHURCH, BRIGHTON.

THE view opposite is to show design of proposed future tower. The lower portion forms porch, and above the ringer's loft, belfry, and water-tank, in case of fire. The church is built of red bricks and red stone dressings outside, and is faced internally with red and white bricks and Bath stone dressings. It is arranged to accommodate 900 persons. The plan consists of nave and aisles, transepts and apsidal-ended chancel with chapels, a baptistery at west end with two entrances—one in tower and one in porch, giving access to nave and aisles. There are also two other entrances, one in each chancel chapel. The vestries are connected by a passage behind reredos. The chancel is floored with marble mosaics, in patterns of flowers and three figures representing Faith, Hope, and Charity. These figures are two-thirds life-size. The stalls and reading desk are richly carved with foliage and figures in American walnut wood. The pulpit is of Caen stone, octagon in shape, on columns and vaulting, with beautifully carved panels in low relief of three scenes from the life of Christ. The font is of alabaster, also sculptured by Mr. Nicholls, and the inscription says it is in memory of the Rev. Julius Elliott, a former incumbent of the church, a son of the founder of the old St. Mary's, which this one replaces. The chancel, transepts, and aisles are vaulted, and the nave has a boarded wooden roof.—*The Building News.*

A BELGIAN PERMANENT EXHIBITION.—On the first of next May a permanent international exhibition will be opened at Brussels, the capital city of Belgium. This year is the fiftieth anniversary of Belgian independence, and the occasion will be largely celebrated by various festivals, and a large attendance at Brussels is expected for next summer. The Belgian government is anxious that other nations should exhibit specimens of manufactured goods and art work.
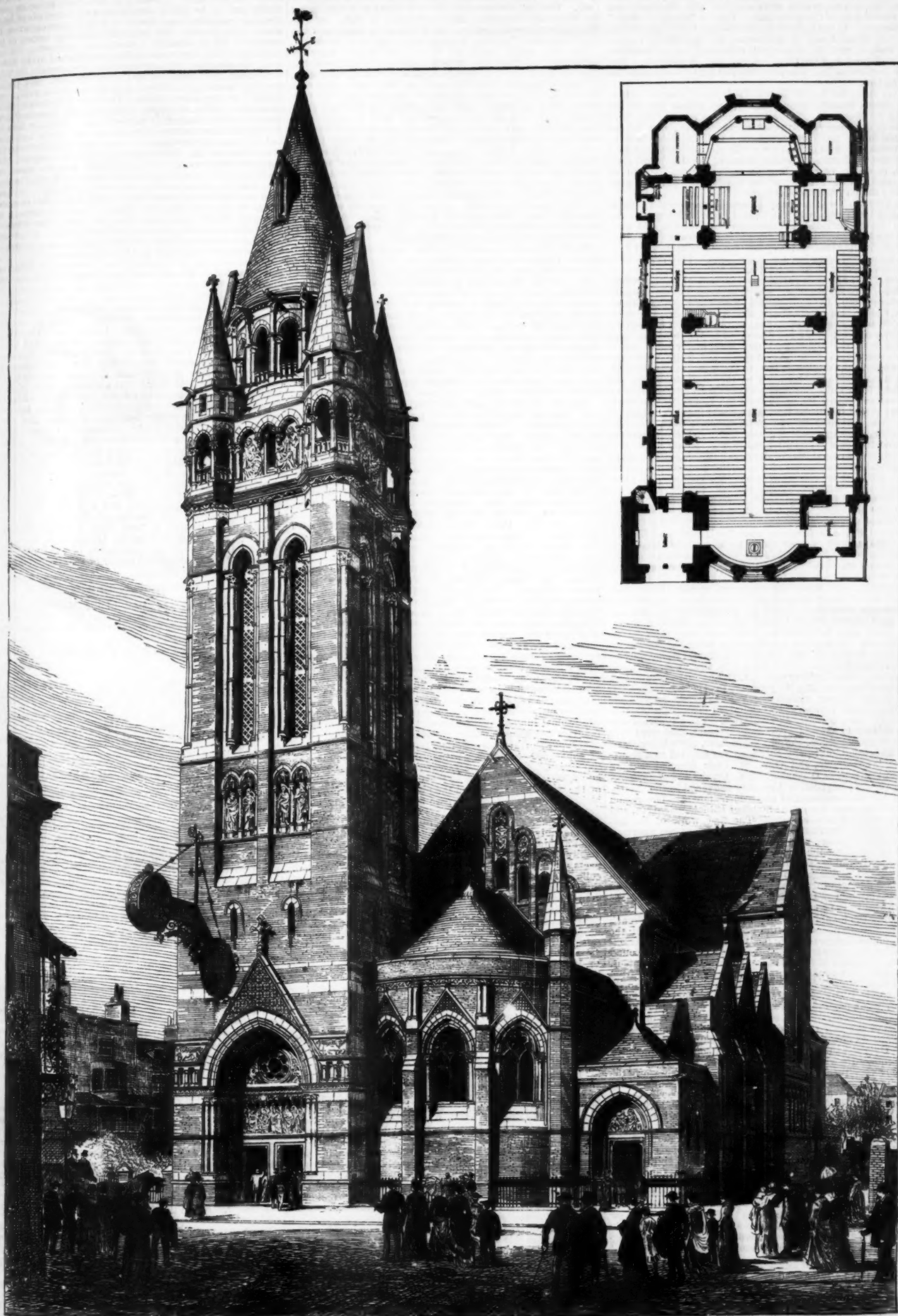
SUGGESTIONS IN ARCHITECTURE.—ST. MARY'S CHURCH, BRIGHTON, ENG.—W. EMERSON, ARCHITECT.

THE OLD NORTHWEST.

LESS than a score of years ago "the Northwest" was the name given to an undefined region lying west of the Alleghany Mountains, which included Ohio and Michigan and the States west of the great lakes. There is to-day a "New" Northwest. It lies beyond the Mississippi River, and claims the rich, fertile lands of Minnesota, the Red River Valley, and Dakota, and its boundaries westward are as limitless and undefined as were those of the Old Northwest. The New Northwest has, however, marked for us the boundaries of the Old.

Ever since the first of March, 1784, when Thomas Jefferson, James Monroe, Samuel Hardy, and Arthur Lee, in the name of the State of Virginia, ceded all right, title, and claim to the country northwest of the Ohio River to the United States, the Northwest took its abode somewhere to the north and west of that river. It was not fully exorcised from the southern and eastern shores of the Ohio until after 1795, in which year an English writer, under the title of "Notes from the Frontier of the Northwest," gave an interesting sketch of life in Kentucky.

In 1784 the Twelfth Congress passed an act for the government of the territory of the United States northwest of the Ohio, which provided that there shall be found in said territory not less than three nor more than five States. The question of dividing this territory into ten States, instead of five, was under consideration for some time. The proposition was even carried so far as to suggest the names of the ten States. If it had been carried out, instead of having Ohio, Indiana, Illinois, Michigan, and Wisconsin, the maps would be adorned with the semi-classical names of Sylvania, Michigana, Chersonesus, Cessenisipia, Metropotamia, Illinois, Saratoga, Washington, Polypotamia, and Pelispia. The territory was first divided into three States. The Western State was bounded by the Mississippi, the Ohio, the Wabash, and a direct line drawn from the Wabash and Point Vincennes due north to the territorial line, to the Lake of the Woods. The Middle State was bounded by the said direct line, the Wabash from Point Vincennes to the Ohio; by the Ohio by a direct line drawn due north from the mouth of the Great Miami to said territorial line, and by said line. The Eastern State was bounded by the last-mentioned direct line, the Ohio, Pennsylvania, and the said territorial line. Having marked out these prospective States, the territory was next divided into five counties or districts. Washington County comprised all that portion of the territory within forty miles of the Ohio River, and between the Muskingum and Little Miami, with Marietta as the seat of justice. Hamilton County comprised all that portion of the territory between the Little and Great Miami within forty miles of the Ohio River, and Cincinnati was the county seat. St. Clair County contained all the settlements upon the Illinois and Kaskaskia rivers, as well as those upon the Mississippi, Kaskaskia being the county seat. Wayne County embraced all the settlements upon the Maumee, Raisin, and Detroit rivers, with Detroit as the seat of justice.

Provision was made by Congress at this time that, should any of these States attain to the size of 60,000 free inhabitants, such State should be admitted by its delegate into the Congress of the United States; provided, if necessary, they may be admitted with even less than 60,000 inhabitants. It was also provided that when the Northwest Territory contained 5,000 free males it should be entitled to a Representative Assembly. Arthur St. Clair was appointed Governor of the Territory Oct. 5, 1787, and three judges were appointed to administer its justice. In 1794 Gov. St. Clair and Judge Tower visited the various white settlements throughout the Territory, and estimated their population to be 15,000 men, women, and children. They reported that the settlements showed great improvement, and were in a prosperous condition. Four years later, there being 5,000 free male inhabitants, the Territory was entitled to a Representative Assembly, and Gov. St. Clair directed that an election be held in December, 1778. On the 22d of January, 1779, the first Legislative Assembly convened in the Northwest. It was composed of nineteen members. The region comprising what is now the States of Illinois, Michigan, and Wisconsin sent two delegates. The first work of the Assembly was to nominate ten persons, whose names were sent to President Adams, who selected from the list five, who were to constitute the Legislative Council, or Upper House, in the territorial legislature for five years. The Assembly next elected a delegate to represent the Territory in Congress, which was then in session at Philadelphia. William Henry Harrison was chosen as the representative of the Northwest in the council of the nation.

In 1800 the inhabitants were much disturbed by French and English trappers along the great lakes, and called the attention of Congress to the fact that the Territory was exposed as a frontier to foreign nations whose agents found sufficient interest in fomenting an insurrection or discontent, as thereby they could divert a valuable trade in furs from the United States. For the better government of the Northwest a new Territory was set off. Chillicothe, on the Scioto River, was made the seat of government of the Northwest Territory, and St. Vincennes, on the Wabash, was made the capital of the new Indiana Territory, which comprised all the territory now occupied by Indiana, Illinois, and Wisconsin. Over the Indiana Territory Harrison was appointed Governor. Its whole population was less than 6,000 souls. In 1803 the Territory, which now comprises what are the States of Ohio and Michigan, was believed to contain 45,000 people. A State organization was formed, and the State constitution was ratified the same year by Congress. The year 1802 was eventful in the annals of the Northwest, not only as being the year in which her first State was born, but this year, also, the first vessel which plowed the waters of the great lakes was launched on Lake Erie. Previous to 1800 the commerce of the Ohio was carried on by eight or ten keel boats, which ran between Pittsburg and Cincinnati; this year it grew rapidly in size and importance. It was noted at this time as a sign of the rapid settlement of the Northwest, that a settler's cabin could be found in the Scioto Valley every ten or twelve miles. A traveler from New England, who visited the Connecticut Reserve, a section in the Territory which had been settled largely by New Englanders, thus sang of its growth and prosperity:

"Here, where but late a dreary forest spread,
Putnam a little band of settlers led;
And now beholds, with patriot joy elate,
The infant settlement become a State;
Sees fruitful orchards and rich fields of grain,
And towns and cities rising on the plain;
While fair Ohio bears, with conscious pride,
New-laden vessels to the ocean tide."

In 1805 the Michigan Territory was set off. It included the present States of Michigan and Wisconsin, and had a population of about 3,500 souls. William Hull was appointed Governor of the Michigan Territory. In 1809 the Illinois Territory was formed, with Ninian Edwards as Governor. Illinois became a State in 1818, and Michigan in 1835. The last Territory of the Old Northwest was called the Wisconsin Territory, and was formed in 1836. In 1848 Wisconsin was admitted into the Union as a State, and the Old Northwest Territory became only a matter of history.

The first steam vessel, the Walk-in-the-Water, made its appearance on Lake Erie in 1819, making trips as far up the lakes as Mackinac. In 1826 a steamboat plowed the waters of Lake Michigan, but it was not until 1832 that a steamboat arrived at Chicago—less than half a century ago. In 1840 the trade of the upper lakes was carried on by forty-eight steam vessels of from one hundred and fifty to seven hundred and fifty tons burden, and by two hundred and twenty-five small sailing vessels. Increasing yearly, with a marvelous rapidity, the lake commerce of the old Northwestern States is now carried on by a fleet of twenty-eight hundred steam and sailing vessels owned by these States, and aggregating a tonnage of four hundred and seventy thousand tons. Their river and canal commerce employs five hundred craft of every description, with a carrying capacity of eighty thousand tons. The port of Chicago alone, which had scarcely an existence forty years ago, now ships yearly articles of commerce valued at $900,000,000.

The first charter granted for the construction of a railroad in Illinois was issued in 1833, but it was not until 1838 that the road was constructed from Springfield to Meredosia, a town on the Mississippi, a distance of about sixty miles. It was not until a year or two later that a locomotive was brought from the East, a part of the road being operated during this time by mule power. Of the eighty-one thousand miles of railroad in the United States at the present time, twenty-two thousand seven hundred miles, or more than one-fourth of the whole number, is in the five Old Northwestern States. These States now make the iron and steel rails for their railroads, build their own locomotives and cars, construct iron bridges across their rivers, and furnish their own railroad supplies.

Together with the lakes and the railroads, the canals have been an important aid in the rapid development of the Northwest. Twelve hundred miles of canals have thus far been made. The question of connecting Lake Erie with the Ohio was considered by the legislature of Ohio in 1822, and an examination into the practicability of constructing such a work was ordered. Three years later a law authorizing the building of two canals, one from the Ohio to the lake by the valleys of the Scioto and Muskingum rivers, the other, from Cincinnati to Dayton, was passed. On the 4th of July, 1825, the ground was broken for the Ohio and Erie Canal, which connects Portsmouth with Cleveland, a distance of three hundred and seven miles. The Miami Canal, one hundred and seventy-eight miles long, connecting Cincinnati with Dayton, was next constructed, and was followed by the Wabash and Erie, which follows the Maumee Valley to Fort Wayne and Terre Haute, Indiana. The Illinois and Michigan Canal, one hundred miles in length, connecting Lake Michigan and Chicago with the Illinois River, was finished in 1848. The last great improvement is the connection of the Wisconsin and Fox rivers, a work recently completed.

One of the first cares of the settlers of the Northwest was to establish schools for the education of their children. One square mile of land, or Section Sixteen, in every township of the Territory, had been reserved by Congress for the maintenance of public schools. Besides this valuable fund, each State has reserved the income from various sources to be used exclusively for educational purposes. The permanent educational fund of these States at the present time is not far from $30,000,000, and is growing in value yearly. One of the old Northwestern States, Indiana, has a school fund of $9,000,000—a fund larger than that of any other State in the Union. These States now have 45,000 school-houses, and 2,500,000 children attend them regularly. In the growth of the common schools, and the establishment of numerous higher seminaries of learning, we mark the intellectual progress of the Old Northwest. It is forty years since Edward Everett spoke so eloquently in Boston for aid in building up the university at Athens, Ohio, the first institution of the kind in the Northwest. To-day a Northwestern university stands first in the country as to the number of students, and the standard of scholarship of many Western colleges has risen to an equality with the oldest colleges of the East.

In the number of their newspapers and periodicals, and the rapidity with which they increase, do we also mark the progress of the old Northwestern States. They have 2,380 newspapers, monthlies, etc., or one-third of all the periodicals published in the States and Territories, not including New York State. Illinois has twice as many daily papers as Massachusetts, and a hundred more weekly papers than the whole of New England.

At the beginning of the present century the territory occupied by these States contained the following population:

Ohio	45,365	Michigan	551
Indiana	2,517	Wisconsin	115
Illinois	2,458		
Total			51,006

The increase in population from census to census forms an interesting study. In 1830 the four States and the Territory of Wisconsin had together a population of over one million. It was not until 1840 that any one of them, the State of Ohio, had a million inhabitants. The increase between 1850 and 1860 was 2,402,624, the largest increase made in any ten years. The increase since 1870 has been about 2,000,000, which will give the Old Northwest, in 1880, a population of between eleven and twelve millions, or not far from the population of the United States in 1830! With the increased population have come wealth and political power. It is, of course, impossible to obtain a correct estimate of the wealth of these States, but it is not far from $11,000,000,000.

The present House of Representatives is composed of 293 members. Of this number 69 are from these Northwestern States. In the redistricting of Representative Districts, which is to be made in 1880, the House will be increased by about 65 members. Of this number one-third will come from the Old Northwestern States, and their political power will be thus largely augmented.

The rapid growth of the manufacturing industries of the Northwest has excited the interest and wonder of the whole country. These States have hitherto been regarded as purely agricultural States, with but few advantages for the establishment of manufactures. But their manufactures bid fair in the next decade to equal in importance their agricultural wealth. They have been found to possess numerous and valuable water powers, superior in their length, in the abundance of water and the uniformity of their flow, to most of the power-furnishing rivers of the East. Located at favorable points on these rivers are to be found hundreds and thousands of busy, thriving manufacturing towns in direct communication, by water or rail, with the great distributing centers of the country. There is hardly a manufacturing industry of importance which is not successfully established in the Northwest. Its situation for securing the raw materials, the hides for leather, wool and cotton for the factories, pork for the packing houses, and wheat and grain for the mills, is not equaled by any other States. These States contain within themselves mines of copper, lead, and iron, immense timber forests, and inexhaustible beds of coal. Not only does the Northwest manufacture many of her own goods, but in the last ten years she has begun to send her manufactures into every State of the Union and into foreign countries. The fleets on either ocean, which are laden with her wheat and grain and pork, are freighted also with her flouring machinery, wagons, water-wheels, wind mills, etc., etc.

In the Old Northwestern States we find churches as numerous as in the New England States. Indeed Wisconsin, the youngest State, has more churches than Massachusetts. The value of church property in Illinois alone is $25,000,000. There are in the five States 20,000 churches, or a church for about every five hundred and fifty inhabitants.

The expression of "going West," which was indiscriminately applied to all who sought a home west of the Alleghany Mountains a dozen years ago, has lost its old significance to all who now seek a home in the Old Northwest. Those pioneer days of privations, log houses, and fever and ague are past. Schools and churches, society and the comforts of civilization are no longer left behind. The railroad goes everywhere, and stage routes seem no more numerous than in New York State or New England. The fertile country has blossomed into thrifty farms, and shanty villages have grown into substantial, prosperous cities. One can find in the Old Northwest a score of cities of 20,000 inhabitants and upward to 450,000 inhabitants, whose first frame house was raised scarcely fifty years ago, but which possess in their fine public buildings, churches and school-houses, gas and water-works, substantial business blocks, elegant residences, and beautiful parks, all those improvements, conveniences, and luxuries which in any other country but our own would be realized only with the growth of centuries. In some of these cities, it is true, the beautiful shade trees of older cities are wanting, but every year is embellishing the streets of these cities with oaks, maples, and elms. Each year country and city alike are becoming more attractive to the dwellers of older cities and State. To-day, less a century by four years since the Northwest Territory was recognized by the Government, we note the fact that the center of the population of the United States lies nearest the geographical center of the Old Northwest.—*Chicago Journal of Commerce.*

THREE points on the coast of the Mediterranean have been proposed for the commencement of the line of railroad across the Desert of Sahara. Morocco, Algeria, and Tunis have each special recommendations, but there is a perfect unanimity of opinion regarding the expediency of making the route, from whatever place it is to be started, strike Insalah, a town which commands the whole line of traffic between the North and Timbuctoo. It is situated on the verge of the desert at the southern boundary of the French possessions in Northern Africa, and it is healthy and well supplied with water. The inhabitants have advanced far beyond the nomadic stage of civilization, and they are desirous of more intimate communication with still more civilized society.

ELECTRO-DYNAMIC TRANSMISSION.

ON a previous occasion we referred at some length to the value of the electric current as a means of transferring the now unutilized power of many waterfalls to places distant therefrom. This application of dynamo-electric and electro-dynamic machines seems, however, to be of such great importance that we do not hesitate to return to it. This we do more especially to urge that it is not alone those places which are situated within a convenient radius of a waterfall that may be supplied with power by electric transfer. There are innumerable situations around our coasts and on the shores of some of our estuaries whereat advantage might be taken of the potential energy of the waters of the high tides. The tide mill was a useful servant in days preceding the advent of the steam engine, but there are now good reasons for thinking that the rejected servant may, in a modified form, have another day. The possession of the modern turbine will remove many of the difficulties belonging to the old wheels, and the appliances which the mechanical engineer has placed in the hands of the modern contractor will make it possible to entertain a project the cost of the realization of which would, in the early part of this century, have been prohibitory.

In order to make use of the rise and fall of the tide for our purpose, three principal things are required: (1) Two large water reservoirs involving usually (2) embankments and separation walls and considerable excavation; and (3) a pair, as a minimum, of turbines. Large excavations can now be made in the materials forming the most of our shores at a very small cost. By means of the modern steam excavator this work has been done in stiff clay at from 4·75 to 8·5 pence per cubic yard. For the necessary dam or wall, concrete may be employed with great economy as compared with the masonry necessary a century since. Turbine wheels are now to be purchased from engineers who have for years made this motor a specialty, and who now make turbines which will give off an effective duty of 75 to 85 per cent. It may, therefore, be safely assumed that the necessary works for utilizing the vertical range of tidal waters may be constructed at a cost vastly less than such works cost when previously employed.

The mean vertical range of ordinary spring tides has a widely different value on different parts of our shores. The greatest available range is at Chepstow, where it is 40 feet; at Bristol it is nearly 40 feet; and in Mount St. Michael's Bay it is 46 feet. These are, however, exceptional cases. At London Bridge it is 19·5 feet, Liverpool 26·0 feet, Portishead 35·75 feet, Holyhead 16·08 feet, Hull 20·82 feet, Devonport 15·5 feet, Portsmouth 12·70 feet, Sheerness 16·0 feet, Harwich 11·5 feet, Great Grimsby 19·16 feet, Leith 16·33 feet, Pembroke 21·5 feet, Weston-super-Mare 37·25 feet, and at most other sea-side places the ranges vary from 10 feet to as high as those quoted. Now, one-half to three-fourths of the tidal range is utilizable as effective head for working water motors. Taking, therefore, the average available working

head as 10 feet, we have, as the quantity of water theoretically necessary to develop one horse power, $\frac{33,000}{10} = 3,300$ pounds per minute. To this, however, we must add, say, 25 per cent. as the difference between unity and the effective duty of turbines, and again 5 per cent. for leakage; and we then have $3,300 + 825 + 165 = 4,290$ lb., or, say, 68 cubic feet of water necessary to develop 1 horse power per minute. The water storage or reservoir area necessary will depend upon the system of working adopted. That which seems to recommend itself most is the system which requires two adjacent reservoirs worked as follows, each reservoir being provided with a pair of turbines, one of each pair being for use in case of derangement of the other. The turbines of each reservoir will be connected by suitable clutch gearing to the same main shafts for operating the dynamo-electric machines. Then, calling the two reservoirs, E and F, we will suppose F to be full high water level, and, further, that it is now high water. The working turbine in E, working by in-flowing water, is started two hours, say, before high water, and thus, having been at work two hours, it will continue to work until, say, half ebb. The turbine in F is then started, that in E stopped, and E allowed to empty itself by a sluice with the remainder of the ebb tide, the sluice being closed at low water. The turbine in F is worked by the water flowing therefrom, and may continue to work until, say, half flow tide, when the turbine in E will be again started, and the process being repeated, a continuous supply of power to the dynamo-electric machines will be secured. By this system of working it will be seen that each reservoir should have a storage capacity equal to that quantity of water which is necessary to supply the turbine for three-quarters of a double tide, or nine hours. In order, however, to allow a margin of capacity sufficient to permit working considerably more than half a single tide by each turbine, we may take the necessary capacity as that which will supply the turbine for twelve hours. We have already seen that the quantity of water required per minute per horse power will be 68 cubic feet. The quantity required per horse power for twelve hours will, therefore, be $68 \times 60 \times 12 = 48,960$ cubic feet, or, say, 1,813 cubic yards. Taking the necessary depth of the reservoirs as 13 feet to allow an available head of 10 feet, we have $\frac{48,960}{15} = 3,264$ square feet as the necessary superficial area of the reservoirs; or, supposing the reservoirs to be square, they would be 57·13 feet on each side. One horse power would not, of course, be of any value, but having the requirements for one horse power, we may easily get at that required for any other number. Taking, for instance, such a town as Devonport, with about 50,000 inhabitants, it will be readily admitted that, for electric lighting and other purposes, the power of 600 horses, or 600 steam-engine-indicated horse power, would be readily utilized. Assuming, and it is very near the truth, that 60 per cent. of the work done upon a dynamo-electric machine is realized from an electro-dynamic machine, then the horse power required would be 1,000. It would be less in proportion to the quantity of electricity that could be used directly for lighting purposes, but we will take 1,000 horse power as being required. The reservoir area required will then be $\frac{48,960 \times 1,000}{15} = 3,264,000$, or a lineal extent of embankment, even if embankment be required throughout the perimeter of the reservoir, of about 7,230 feet, and requiring but 1·8 million cubic yards of excavation. It would, however, happen in most cases that the earthen embankments left by the excavation would answer all requirements, except just at the sea face and at the turbine house. Taking one horse power as vendable at the very low rate of 6d. per horse power per day, then we have a rental of £15 per day, or, for only 300 days per year, an income of £4,500 per annum. This, capitalized at 8 per cent., equals £56,250. Thus, taking the extent of the necessary reservoir work (the most costly) at the very extreme estimate, it may be assumed, without entering into the details of cost of machinery—details which we may leave to our engineering contemporaries—that the cost of works and apparatus would leave a very large margin for profit. Sufficient, at least, has been said to show that there is a great future for the employment of dynamo-electric machines in connection with hydraulic engineering work, and it may be safely said that tidal power may be almost as efficiently and cheaply utilized for 20 as for 2,000 horse power.—The Electrician.

SPECTRUM OF THE ELECTRIC SPARK BETWEEN MAGNESIUM POINTS.

PROFESSORS LIVEING and Dewar have been examining the spectra of magnesium in hydrogen with the following results. The discharging points were pieces of magnesium wire. Round one end of each a platinum wire was tightly coiled and fused into the side of a glass tube. This tube was attached by fusion at one end to another tube filled with phosphoric anhydride, which in turn was connected with a Sprengel pump. The other end of the tube, with the wires, was connected by a thick rubber tube, capable of being closed by a pinchcock, with a gas holder containing nitrogen over strong sulphuric acid. The tube having been exhausted and filled with nitrogen two or three times, it was found that no line at 5,210 (wave length) was visible in the spark. The tube was now gradually exhausted, and the spark watched as the exhaustion proceeded. No line at 5,210 was seen, although the exhaustion was carried nearly as far as the pump would carry it; nor was any hydrogen line (C or F) visible, either with or without the use of a jar. The communication with the gas holder was now opened, and the tube refilled with nitrogen at the atmospheric pressure. A communication was then made with another vessel containing hydrogen, which was allowed to diffuse into the tube for a very short time. On now passing the spark, the line at 5,210 at once appeared, although the quantity of hydrogen diffused into the nitrogen must have been very small. The experiments with nitrogen at reduced pressure were repeated several times with the same result. It was found necessary to have the phosphoric anhydride, as without it traces of moisture were left or found their way through the pump into the tube, and then, when the exhaustion was carried far enough, both the line at 5,210 and the hydrogen lines, C and F, made their appearance. We have never, however, been able to detect the line at 5,210, in nitrogen, without being able to detect C or F either at the same time or by merely varying the discharge by means of a Leyden jar. Experiments made in the same way with carbonic oxide instead of nitrogen led to precisely similar results. The line at 5,210 is not seen in the "arc" in a lime or carbon crucible when magnesium is dropped in without the introduction of hydrogen. If, however, a gentle stream of hydrogen or of coal gas be led in through a perforation in one of the electrodes, the line at 5,210 immediately makes its

appearance, and, by varying the current, it may be made to appear either bright or reversed. However small the current of hydrogen be made, the line can be detected as long as the current and the supply of magnesium continue, and disappears very quickly when the current ceases.

THE TEMPERATURE OF THE CARBON POINTS IN THE ELECTRIC LAMP.

EARLY in the development of the electric light a difference was observed in the appearance of the two carbon terminals. The positive was blunt and hollowed out in the center; the negative was conical, pointed, and covered with the particles disintegrated from the positive. This, together with the difference of brilliancy noticed when the image of the carbons was projected on a screen, led to the same conclusion, viz., a difference of temperature between the incandescent points.

In 1844, Foucault and Fizeau wrote a paper upon this subject, in which they described the general phenomena, but gave no data from which the heat condition of the two poles could be inferred. It was not until 1862 that any careful measurements were made. In that year, the late M. Becquerel made a series of experiments on the temperature of the positive carbon. The current was supplied by a battery of 80 middle size Bunsen cells, and the temperature was taken at the moment the light flashed forth. M. Becquerel concluded that this temperature was not constant, but that it varied between the limits of 2,070° C. and 2,100° C. Unfortunately, an assumption was made by the French physicist which has since been disproved, and hence the above figures have not been generally accepted.

It may be remarked that this determination is beset with considerable practical difficulties. The radiating surface must be small—a mere slice of the glowing carbons, and yet it must be measured with great accuracy. M. Rosetti, an Italian physicist, who has been following up the work begun by the late Professor Henry and Father Secchi on the temperature of the various parts of the solar disk, has recently applied his method to this electric problem. He has found that the temperature of the incandescent carbons, at the moment of ignition, is not the same throughout, and is affected by a variety of circumstances, e. g., the thickness of the terminals, the number of cells in the battery, the way in which they are coupled together, and the time they have been charged.

Thus, in one series of experiments, the temperature of the positive terminal was found to be 2,980° C. By using a thinner terminal, it rose to 3,065° C.; and, by changing this for a third of still smaller dimension, it reached 3,136° C.

The effect of the number of cells in the battery on the temperature is shown in the following table:

Number of Cells.	Temperature.
80	2,784° C.
70	2,536° C.
60	2,334° C.
50	2,190° C.

Foucault showed photometrically that the light produced by a battery of 80 Bunsen cells lost one-third of its intensity in less than three hours. Hence M. Rosetti was obliged to make a large number of determinations, including all the varying conditions above mentioned, before he could arrive at any very definite conclusion. In every case, however, he found the temperature of the positive pole higher than that of the negative; and, summing up his experiments, he concludes that the temperature of the positive carbon point cannot be less than 3,200° C., while that of the negative is at least 2,500° C.—Engineering.

A NEW ELECTRIC BURNER.

By M. PERRUCHE.

THE burner itself, or candle, is composed of three cokes, of which two are cylinders, while the third has a square section. Two of them are in close contact during the combustions, and form only a single electrode. The third is placed upon a line bisecting the angle formed by the other two, and forms the other electrode.

THE HIGHEST MAGNIFYING POWER EVER REACHED.

ALMOST the first question asked by those to whom a microscope is shown, provided they are not familiar with the instrument in its different forms, is, "How much does it magnify?" and the next question generally is, "What is the highest magnifying power made?" and even to those who have a general knowledge of the subject, the question, "What is the highest magnifying power that has ever been reached?" is one of more than usual interest. We propose to tell what we know about the subject, and will be glad to hear from others who have additional facts within their knowledge.

Of simple microscopes, we suppose that those which magnified most (at least so far as any record exists) were the ones sent by Di Torre, of Naples, to the Royal Society of England. Coddington tells us in his "Optics" that one of them was said to magnify 2,560 diameters, and the maker claimed that he had been successful in using it. But Baker, to whom it was intrusted for examination and report, said that he could do nothing with it, and that several earnest attempts to use it had seriously injured his sight. It is more than likely that the power to use such small lenses will depend greatly upon the conformation of the eye of the observer, and Di Torre may have had exceptional visual organs.

Of compound microscopes, the highest magnifying power reached, so far as we know, is 100,000 diameters. This was obtained about ten years ago by Mr. Edward Dickerson, of this city, and was publicly exhibited to several of his friends and acquaintances. The New York Sun published a long article upon the subject, and described the appearances which ordinary objects, magnified to this degree, might be supposed to present. Thus, a single human blood corpuscle, if magnified 100,000 times, would be over thirty inches in diameter, or the size of a small cart wheel. A human hair, seen under such a power, would rival in appearance the giant trees of California, for it would be over forty feet in diameter. A fly would appear as a monster, three-quarters of a mile long, and the claws of a honey bee would stretch across our widest streets and clasp the houses on both sides, like huge grappling irons.

This style of writing, which is very common among pseudo-scientific writers, conveys entirely erroneous ideas as to the results which could be obtained by such powers. For example, it would be utterly impossible to obtain a complete view of a fly, even with a magnifying power far

less than that here described; a small part of one of the facets of the fly's eye would fill the whole field of view, so that the fly itself would not "appear" at all.

That Mr. Dickerson did obtain a power of this extent, there is, we believe, no doubt, but, as may easily be imagined, no results of any value were ever obtained by it. The power was obtained in the old way, carried, however, to extremes. A high objective (a fifteenth, we believe, in this case), a high eye-piece, a long tube, and an amplifier. The furthest it could go in resolving power was the P. angulatum, and this was resolved into dots. Photographs and models of the angulatum as thus seen were exhibited, but the photographs were not made by the microscope, but were from drawings or models. Descriptions of the wonders that might have been exhibited were freely quoted in the daily papers, and the echo of these accounts reverberated through the scientific press of Europe. But of so little real value were the actual results that, although all this occurred only ten years ago, it has long since been forgotten.

Of the magnifying powers used by those who have achieved notable results in microscopy, the following deserve notice:

Raspail carried the use of the single microscope as far as it could go, and 150 to 200 diameters was, we believe, the limit of his power. His remarks upon the value of high powers are interesting and instructive, and we shall recur to them again before long.

The highest recorded magnifying powers procured by means of compound microscopes are, we believe, those which have been used by Dr. Beale. He has employed successfully a magnifying power of 10,000 diameters, and claims that powers lower than 2,000 to 5,000 diameters are insufficient in many cases. The objectives used by Dr. Beale are a 1-16th, a 1-25th, a 1-50th, and a 1-80th. He uses long draw tubes (24 inches) in preference to high eye-pieces, and he does not use an amplifier. It seems to us, however, that where such long tubes are used, the observer should use an amplifier, so formed as to correct the aberrations introduced, unless his objectives have been specially constructed with a view to the employment of such tubes.

In this connection an interesting question arises in regard to the limit of magnifying power that may be obtained with lenses of a given quality. If we wish to use a magnifying power of 10,000 diameters, is it best to use a 1-10th objective, and bring up the power with amplifiers and eye-pieces, or should we use, say a 1-25th, with eye-pieces, of only one-fourth the power? Another question is: To what extent can we magnify the object when we use second-class objectives? In other words: Suppose we are using a quarter-inch objective, of fair but not first-class quality, can we see more with a power of 2,000 diameters than one of 1,000 diameters? Or, in other words:

With what power can we see most of the fine details of an object, one of 2,000 diameters, or one of 1,000 diameters? Will the increase beyond 1,000 diameters result in such deterioration of definition as will more than make up for the increased amplification?—American Journal of Microscopy.

A CHEAP AND SIMPLE CAMERA FOR THE MICROSCOPE.

THE following description of a capital little device has been sent to us by Mr. T. B. Jennings. Any of our readers can make the accessory for themselves. Where the eye-piece is not furnished with a cap there is generally a milled ring which is larger than the tube of the eye-piece. In this case it may be necessary to wind a narrow strip of paper round the eye-piece so as to make it of equal size for at least a quarter or three-eighths of an inch from the upper end. Mr. Jennings writes:

Probably there is nothing that will assist the student in microscopy so thoroughly as drawing the object, as he thereby fixes the different parts in his mind.

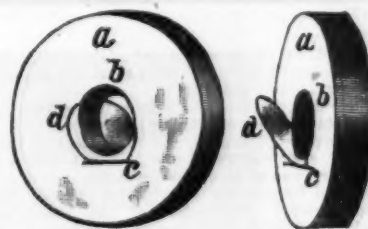A good camera lucida is too expensive for many persons,

FIG. 1.   FIG. 2.

CHEAP CAMERA LUCIDA.

while other and more necessary accessories are being purchased.

Having made a good reflector for my own use at no expense, and thinking that many of your subscribers might desire to do the same, I give the mode.

Take a flat cork, Fig. 1, a (mine was from a large-mouthed bottle), cut a hole, b, through its center large enough to fit over the eye-piece after the cap has been removed. Just below the hole make an incision, c, so that it will hold a thin glass cover, d, at an angle of 45°. I use a cover three-quarters of an inch in diameter.

The "reflector" can be easily removed when not in use, and the glass readily taken out to be cleaned. Fig. 2 is a side view.—Amer. Jour. of Microscopy.

ON THE NUMBER OF VIBRATIONS NECESSARY FOR THE RECOGNITION OF PITCH.

By PROF. A. E. DOLBEAR, Tufts College.

THE smallest number of vibrations necessary to produce the sensation of a continuous sound have been variously estimated by different investigators. Savart set it at seven or eight per second, while Helmholtz made it as high as 30 per second. These estimations must be considered as purely individual ones, depending upon the capacity to perceive sounds, which is markedly different in different persons. Granting the sympathetic vibration theory of the rods of Corti, it is plain that greater sensitiveness of these rods would insure that they should retain the energy of the impulses a longer time, just as a sympathetic tuning-fork not only respond quickly, but continues to vibrate for a time after the originating impulses have ceased. A very sensitive ear might be expected to perceive a continuous sound with a

smaller number of vibrations per second than a less sensitive one.

The pitch of a sound may be defined as the rate of vibration per second. The absolute number per second being of no moment, a C tuning-fork making 512 vibrations in a second would give the same pitch if it vibrated for only half a second or a less fraction; but, what is the least number of vibrations that will enable an ear to detect pitch?

Theoretically, there can be no rate, and consequently no pitch, to a single vibration. It is essential that there should be two or more to establish a rate, and, to be heard as continuous, must follow each other with an interval not greater than the perception limit, which varies in different individuals, as mentioned above. For the average individual it will probably not be greater than $\frac{1}{10}$ of a second, otherwise they would be heard as distinct pulses without pitch.

With the ordinary apparatus for the study of sound, such as forks, pipes, or siren, it is impossible to determine this low limit experimentally, as they cannot be made to sound for so brief an interval as to make but a few vibrations; but, with the following device, I found no trouble in recognizing pitch with only three or four vibrations. Let the finger nail be drawn across a piece of ribbed paper or cloth such as many books are now bound with, and a whistling sound will be heard, and the pitch may be readily determined. Of course it will vary with the velocity of the hand. The number of ribs passed over in a given interval of time must give the number of vibrations; but, to perceive the pitch, it is necessary to touch but three or four of these, which was determined by using a lead pencil and a light colored piece of ribbed paper. The pencil recorded the number of ribs touched. The rate was such as to be not less than 1,000 per second, and consequently the whole interval was but $\frac{1}{250}$ or $\frac{1}{330}$ of a second. I was able to touch only two at a trial, else I have no doubt they would have been sufficient to enable me to perceive the pitch; but, as the difficulty seems to be purely a mechanical one, there is no good reason for believing that more than two vibrations are requisite for the recognition of pitch.—*Journal of Otology.*

THE TOUROSCOPE.

THIS instrument is for the purpose of exhibiting plain and colored transparencies and lantern slides, singly, or in combination with each other, and is capable of producing some very rich, beautiful, and even surprising effects.

It consists of a very fine, large lens, similar to those used in the graphoscope, with a dark chamber, in connection with (what is its greatest novelty) a system or series of slots or grooves, for the insertion of the glass or other transparent pictures to be looked upon.

Referring to the drawing: at A are three or more receptacles for the pictures. At B a thin plate of plain or colored ground glass is inserted, in order to soften the effect of the light which is transmitted through the pictures. At C is a
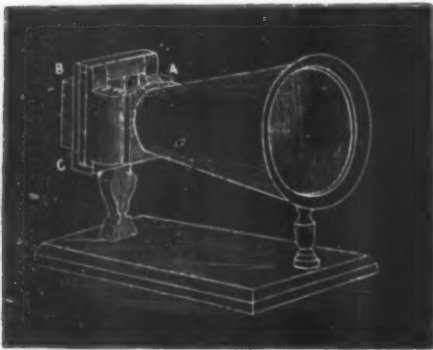
larger receptacle for the same purpose as those at A, only of a size to accommodate such pictures as are mounted in wood, as many lantern slides are.

To produce the intended effects in endless variety, a picture—say of statuary—is inserted in the first slot at A. Now examine its lovely appearance, and then insert in the next slot, behind it, a view of an interior of a cathedral or a picture gallery, and you at once find the statuary piece to have new beauty and interest, for it is located properly in some harmonious interior. The effect of the whole is now heightened by placing a blue, or red, or golden tint in the groove next behind, or at C.

Or the first picture may be a view with splendid foreground and empty sky. Natural clouds may be made to treble the effect by placing a cloud transparency behind the other, and the tinter may then be used or not, as you please. Or it may be you have a beautiful waterfall in first which you can variously tint, and then from its foaming face bring out a splendid statue, with effect almost equal to that of a dissolving lantern. Sunset, sunrise, and moonlight effects may be added to properly chosen landscapes, and day turned into night, and *vice versa.*

The majority of the effects obtainable with a lantern may be secured with the touroscope, and the number of changes possible with it are only limited by the genius of the one working it and the quantity of pictures at hand to work with.

To those who have a variety of transparencies it will be particularly welcome, for by its means they can be used at day or night, and in any light, just as effectively, and as well singly as in combination.

If the portrait photographer would have one on his reception-room table, with a few portrait and other transparencies, he could, by properly pushing the thing, sell many transparencies from his negatives, and touroscopes to exhibit them in. Here is real business for those who want it. Undoubtedly the touroscope, if taken hold of, will open up a new avenue for the growth of photography, and create a demand for a new style of picture. Neither the stereoscope nor the graphoscope was much thought of at first, but see what wonderfully profitable things they have been for our art.—*Phil. Phot.*

PHOTOGRAPHS OF MICROSCOPIC OBJECTS.

THE credit for the excellent article entitled as above, which appeared on page 3404 of SUPPLEMENT, No. 214, was inadvertently omitted. It was written by Carl Meinerth for the St. Louis *Practical Photographer.*

THE SUN'S RADIANT ENERGY.

By S. P. LANGLEY, Allegheny Observatory, Pa.

WHEN the spectrum is allowed to fall on a sensitive plate we can, as has been mentioned, obtain a photograph of it, but, unless special means are used, not of all the lines. The photograph obtained with the salts of silver will fail altogether to reproduce the yellow part; will show something of the green and nearly all of the blue; while up in the violet end the picture is very clear, and beyond the violet, where to all appearance the spectrum has ended, a host of sharply-defined lines comes out on the plate from a region where the keenest eye sees nothing whatever. This is when the instrument is directed full on the sun (not necessarily on its edge, as in a former experiment), and it would appear at first as if there must be in the white sunlight a special kind of rays, which produced not colors or vision, but chemical changes on the plate, printing there images of the slit, which were produced by something quite different from light.

Fig. 26.
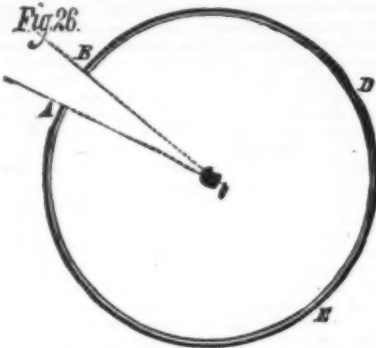
If, on the other hand, we take a delicate thermometer or a radiometer, and move it into successive parts of the spectrum formed by a prism, we find little effect in the blue, more in the yellow, still more in the orange, and as much or more quite beyond the red, where, too, the eye sees nothing. Again, it seems at first that here is another kind still of radiation, causing heat, and which is distinct from that producing light, since one appears where the other does not. In some text books yet in use, diagrams even are given to show the amount of chemical, light, and heat rays in the different parts of the spectrum; but quite recently students of science arrived at a better understanding. The results of old and modern investigations are now seen to point to one conclusion. Given in general terms, this may be said to be that there is, in reality, no such thing as a chemical ray, a light ray, or a heat ray; there is nothing but radiant energy—motion of some kind, causing vibrations across space of something between us and the sun—something which, without understanding fully, we call "ether," and which exists everywhere, even in the "vacuum" of a radiometer. These vibrations are measurable with great accuracy (by processes of which an explanation would be here out of place), and are found to be extremely small in all cases, but to vary among themselves, somewhat as those coarser ones do which have been long known to produce sound. As the high notes of a piano are caused by the rapid vibration of strings, and the low notes by comparatively slow ones, but the sound, whether acute or grave, is due to one thing—motion of the air; so the miscalled "chemical" or "actinic" rays, as well as those which the eye sees as blue, or green, or red, and those which the thermometer feels, are all due to one thing—motion of the ether. Rapid motions exist, which set the molecules of silver vibrating, and are registered by the photograph. These fall also on the eye and on the thermometer bulb or radiometer, and produce some kind of mechanical effect in a minute degree, but not one which those instruments are fitted to register. The longer radiations in turn are not themselves "heat," any more than those which the retina of the eye responds to and calls "light." We have always one and the same cause—radiant energy; and we give this one thing different names: "actinism," "light," or
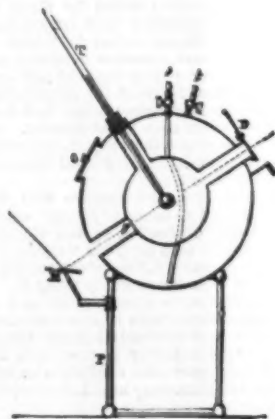

FIG. 27.—SECTION OF CALORIMETER.

"heat," according as the instrument which reveals its presence to the mind is some chemical substance, the retina of the eye, or a thermometer.

It will appear from what has just been said, that there are substances which respond to some of the ethereal vibrations and not to others. The substance which is most generally useful in receiving and, so to speak, absorbing them, is perhaps that which has been recently put to such remarkable use by Edison—common lampblack. Let us try to measure the sun's radiant energy by measuring all of it we can get in the form of heat, and endeavor in the process to reach some idea of the temperature of its surface. There are many ways of measuring the heat, one of which, convenient for its exposition of principles, we give here, though it is not perhaps the best in practice, returning to other methods later.

Thus, in Fig. 26, let A B D E be a large hollow sphere,

inclosing a small thermometer at its center, t. The bulb is carefully covered with lampblack to enable it to absorb as many radiations as possible, and the inside of the sphere is blackened in the same way. Suppose the temperature of the whole at first to be that of absolute cold or at the natural zero, and that the sphere is kept at that, whatever happens. If we remove a given part of the sphere, let us say one-twentieth of the surface area, A B, and fill the aperture with a piece of white-hot iron, this will send heat to t, and the thermometer will rise, though not to the temperature of the iron, which, for the sake of illustration, we will call 2,400°. If the whole sphere were at 2,400° the thermometer would also shortly register this (provided we could make one to stand it), but in fact it is receiving such heat from one-twentieth of the sphere only, and giving it

FIG. 28.—CALORIMETER.

out by reradiation from the bulb to the other nineteen-twentieths, that is, to the whole cold surface around it, which returns nothing. In this case, then, the temperature of the thermometer will be found by reflecting that it gives out very nearly twenty times as much heat as it receives, and that it must register nearly $\frac{2400}{20}$°, or 120°. On the other hand, suppose we, in a new experiment, find the thermometer reads 100°, and want to know the temperature of the iron. We must find what proportion the hole, covered by the hot iron, bears to the whole sphere, and multiply the 100° by this. Were the hole, for instance, in this case but one-thirtieth the size of the sphere, evidently the temperature of the hot iron must have been about 3,000°. If the iron were ever so distant, provided it filled the whole aperture to an eye placed where the bulb is, no external rays could fall on t except from it. It is immaterial, then, in this experiment, whether the hot body is near or far, provided the hole is always kept so small that no foreign radiation enters. The reader will see the bearing of this when he reflects that if we turn the opening in the sphere toward the sun, with the above precautions, the result will be just the same as if we had plugged the aperture with a simple piece out of the sun's photosphere and of its actual temperature. We have now only to multiply the thermometer reading by the number of times the surface of the sphere is greater than the hole, and we have apparently found the real temperature there, as exactly as if we had reached across space and dipped our thermometer bulb into the actual surface of the sun.

There are many drawbacks to this plan in practice, and it is only in case radiation and temperature are proportional that it is sound in theory. Variously modified, however, it is much relied on by experimenters. Fig. 27 gives an internal, and Fig. 28 an external view of the latest construction adopted by M. Violle, of Grenoble, a distinguished recent investigator. In practice the simplicity of our first illustration is widely departed from, and the use of the instrument is much modified. T is the thermometer, whose bulb is at the center of a double sphere maintained at 0° (Centigrade) by a current of ice water circulating through tubes, ff, or by ice put in at O. D is a diaphragm with various apertures; M, a mirror, in which we view the reflected image of g; g is

Fig. 29.
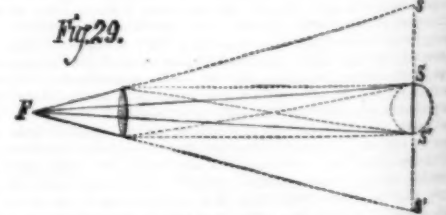
ACTION OF LENS.

a piece of ground glass, on which the shadow of the thermometer bulb falls when the instrument is correctly pointed to the sun. This instrument is capable of being used to give us (according to the method just explained) the temperature of the sun, or else the number of units of heat it sends out. The latter result will be presented, however, by another method subsequently, but before we can do either accurately we must find out how much heat is absorbed by our air. To do this, M. Violle has taken his whole apparatus to the summit of Mont Blanc, and finds there the radiant heat from the sun to that below almost exactly as 4 to 3. The total heat at the boundary of our atmosphere is, according to him, something like one-half greater than at the sea level, a rather larger result than one obtained by another means, to be given later.

To find the temperature of the sun from such an apparatus we virtually multiply the thermometer reading by the fraction expressing the ratio of the surface of the sun's disk to that of the celestial sphere, a ratio which is rather less than 1 to 180,000. In the observations of Soret, on Mont Blanc, the inclosed thermometer read nearly 38° Fah above the temperature of the inclosure, and hence the temperature

of the sun's surface would appear to reach at least the enormous number of $38° \times 180,000 = 6,840,000°$ Fah. The more prolonged and elaborate experiments of Mr. Ericsson give a temperature of about 4,000,000° Fah., and indicate that each square foot of the solar surface radiates over 300,000 units of heat per minute; in other words, each foot can furnish heat equal to that required to drive a theoretically perfect heat engine of over 7,000 horse power. There is a very fair agreement among all experimenters as to the amount of heat radiated, but a wide discrepancy as to the temperature, the very same data which above are interpreted as meaning 4,000,000° Fah. being asserted by distinguished French physicists to indicate less than 4,000° Fah. This monstrous disagreement is not due to any considerable error of measurement—all are pretty well agreed on that—but to our ignorance of the laws connecting temperature and radiation. There are two rules in use, one of which was given by Sir Isaac Newton. It says, in substance, that if a body be raised to double its former temperature, it will radiate double its former heat. The other, given by the French physicists Dulong and Petit, is in the shape of a complex formula, which virtually declares that if a body be raised to double its former temperature it will radiate more than double its former heat; in case both temperatures are high, enormously more. Proving that we get enormous heat from a limited area of the sun's surface, then, does not, in the eyes of some physicists, prove that area to be proportionately hot.

In this there is involved a very practical consideration for us, for this apparently abstruse physical question has a bearing on the duration of the human race, since that duration depends not merely on the present heat of the sun, but largely on the rate at which the sun is spending heat. Suppose some benumbed wanderer to find himself before a fire which seems as if miraculously burning for him, in a cheerless waste, where he would otherwise perish. A fire of straw may be for the moment as hot as a fire of coal; but as the first will spend its stock of heat at once and leave him to die of cold, and the second will spend it slowly and warm him for indefinite time, it is an important thing for him to know the rate at which his fire burns, and this is our own case. The human race—however it came here—finds itself before such a fire, and thus dependent upon it; for it lives on a planet whose proper surface temperature in the absence of solar radiation is variously estimated at from 70° to 273° below zero; and we are all warming ourselves at the sun, without which we should promptly die.

Fig. 30.

SECTION OF A POLYZONAL BURNING LENS.

Let us come back to the question of the sun's temperature, then, with a sense of its personal interest to us. We should know more about it if we could carry our thermometer nearer to the sun, but we can practically do so by means of a burning lens, Fig. 29, where S F S' is the real angle subtended by the sun, s F s' that which it is made to appear to subtend by the lens, so that the effect is nearly that which would be produced by approaching till the solar diameter filled S S'. The actual construction of the burning glass on a very large scale is not now common, as we have other ways of producing intense heat always at command. When made at present they are built up in sections, as in Fig. 30, so as to avoid the necessity of an enormously thick and expensive lens. Such a one as this, in which the lens subtends an angle of about 30°, as seen from the focus, is capable of melting platinum and the most refractory surfaces; and as a great deal of the heat is absorbed by the glass or otherwise lost, if we could approach the sun till it filled such an angle to the eye, we should find the temperature even higher. It is probable that few of the materials of which the crust of the earth is composed would remain in the solid form if carried very much nearer the sun than the presumed orbit of the hypothetical "Vulcan;" and it may be remarked in passing that it is not unlikely that, in case such an intra-mercurial planet as Professor Watson is said to have recently discovered had an orbit whose nearest approach carried it within 10,000,000 or 12,000,000 miles of the solar surface, it would prove to be heated to the point where it would be self luminous.

The writer, some time since, made a comparison of the light of the sun with that given from the molten steel in the Bessemer converter. This was chosen as an example of the greatest temperature attained on the large scale in the arts, and it is one which is known to equal that at which platina melts. Looking down the mouth of the converter we see at one stage of the process a stream of molten iron poured into the vessel in which the melted steel is already glowing in the background. Every one knows how bright white hot (and still more melting) iron appears, but in this case the steel is so much brighter, that the fluid iron in front seems like thick chocolate poured into a white cup. The steel, just before it is itself poured, seems of sun-like brilliancy, until we come to compare it with the sun itself, which was done by means of a photometer, so arranged that the steel light alone is at one side and the sunlight on the other. When the angle subtended by each source of light was equal, the image of the molten steel was put out by the presence even of much enfeebled sunshine, and ceased to be visible, as the dull flame of an alcohol lamp would be if it were set beside an electric light. The area of glowing metal exposed was considerably over one square foot, and measures made with

every precaution showed that any single square foot of the solar surface must be giving out much more, at any rate, than one thousand times the light that the melted steel did.

We are not, it is true, entitled to conclude from this that the heat is in exactly the same proportion, but we are justified by inference from this, and by other experiments not here given, in saying not only that the temperature on the sun's surface is far higher than that reached in our furnaces, but that the heat is in fact so enormously greater than any furnace heat here that they can scarcely be made the subjects of comparison. Other considerations, on which we cannot now enter, give the best grounds for belief that this heat is likely to be kept up sensibly at its present rate of emission for a period which, with reference to the brief history of the human race, may be called almost infinite. These are important conclusions, whose practical bearing will be more fully developed in what follows.

When we watch a gentle summer rain, does it ever occur to us that this familiar sight involves the previous expenditure of almost incredible quantities of energy, or do we think of a drizzly day as perhaps calling for a greater exertion of Nature's power than an earthquake? Probably not; but these suppositions are both reasonable.
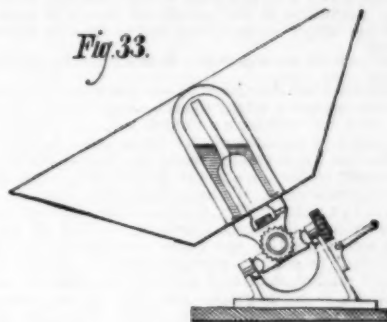

Fig. 31.

THE PYRHELIOMETER.

Take Manhattan Island, for instance, which contains 20 square miles, and on which one year with another over 20 inches of rain falls. (To be within the mark we will call the area 20 miles, and the annual rainfall 30 inches.) One square mile contains 640 acres, and each acre 43,560 square feet. Multiplying by 640 and dividing by 12 we have 2,323,200 as the number of cubic feet of water on 1 mile in a rainfall of 1 inch, and as a cubic foot of water weighs $997 \frac{137}{1000}$ oz. avoirdupois, and there are 35,840 oz. to the ton, this weighs $\frac{2,323,200 \times 997\cdot137}{35,840}$, or, in round numbers, 64,636 tons (to 1 mile and 1 inch of rain). As there are 20 miles and 30 inches, the annual rainfall on this little island is 1,393,920,000 cubic feet, or 38,781,600 tons. The amount of this may be better appreciated by comparison. Thus, the pyramid of Cheops contains less than 100,000,000 cubic feet and weighs less than 7,000,000 tons, and this water, then, in the form of ice, would many times replace the largest pyramids of Egypt. If we had to cart it away, it would require 3,231,800 cars, carrying 12 tons each to remove it, and these, at an average

Fig. 32.

ERICSSON'S SOLAR CALORIC ENGINE.

length of 30 feet to the car, would make 6 trains, each reaching in one continuous line of cars across the continent, so that the leading locomotive of each train would be at San Francisco before the rear had left New York—a result which appears at first so incredible that it seems best to give the figures on which we rest the statement.

Now this is for a very small part of a single year's work of the sun in raising water to produce rain on the little spot of Manhattan Island alone—a spot, geographically speaking, hardly visible on the map of the country. Again, $\frac{1}{10}$ of an

inch of rain spread over the whole area of the United States is not an extraordinary day's rainfall throughout its territory, but it will be found by any one who wishes to make the computation that such a day's rain represents a good deal over the round sum of ten thousand of millions of tons, and that all the pumping engines which supply Philadelphia, Chicago, and our other large cities, dependent more or less on steam for their water supply, working day and night for a century, would not put it back to the height to which it was raised by the sun before it fell. Every ton was lifted by the silent working solar engine, at the expense of a fixed amount of heat, as clearly as in the case of any steam pump, and this is the result of an almost infinitesimal fraction of the heat daily poured out from the sun! Now heat is something men have only in quite modern times learned to think of as a measurable quantity, and we must remember that we cannot even begin to have accurate knowledge of any form of force till we can answer the question, "how much" about it, not vaguely, but in figures.

When we hold the right hand in warm water, the other in cold, for a few moments, and then plunge both in the same basin of tepid water, the two hands will give different reports; to the right the fluid is cold, to the left it will feel warm, though it is the same really to both, and we might vary the experiment by trying it with shade and sunshine. In either case the experiment would convince us that our sensations were very untrustworthy, and that if we were going to measure the sun's heat we must depend on some sort of instrument and not on anything that can feel. The first things we have to do about the sun's heat is to measure it, not to guess at it—to measure it as accurately as we would anything which we could try with a foot rule or put in a pair
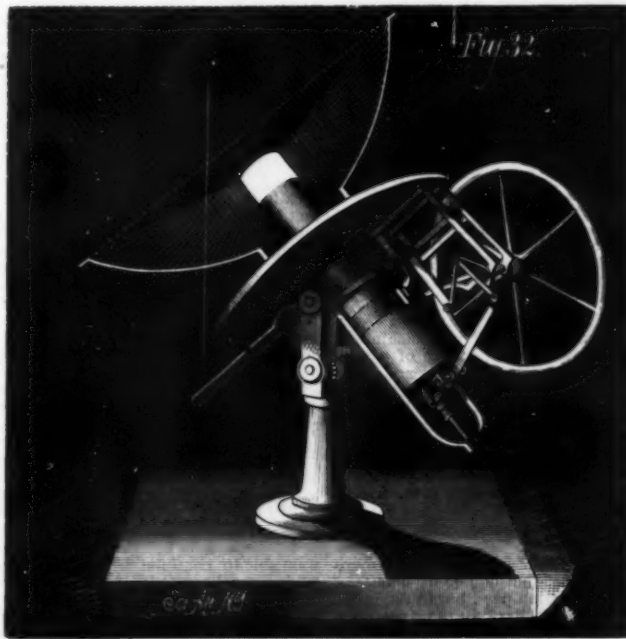

Fig. 33.

of scales. When we have done this we have a solid foundation to work on, and the doing this has been thought a worthy occupation of a considerable part of their lives by many able men.

One of the first of these was Pouillet; others, such as Saussure and Herschel, had been at the problem before him, but his results were the most accurate until very recently, and even recent work has not materially affected his conclusions.

His instrument is easily understood with a little attention. We have it represented in Fig. 31. Let us first remark, that what we want to get is the sun's direct or radiant heat, quite irrespective of that of the atmosphere around us, and that to get definite results, by our present method, we want to know how much of this radiant heat falls on a given surface of one square foot or yard. We may reckon it by any one of the numerous effects heat produces; practically it is convenient to let it warm water, and to see how much it heats, through how many degrees, and in how many minutes.

Pouillet's pyrheliometer is substantially nothing but a very shallow cylindrical box, A A', filled with a measured quantity of water. It is mounted on the end of a hollow rod, having at its other extremity a metal disk of the same size as the water box. When the shadow of the box exactly covers the disk the instrument is pointed true on the sun. Held in the hollow rod is an inverted thermometer, whose bulb is within the water box, A A'. This enables us to read the temperature of the water from moment to moment. It is not enough to expose it for a time to the sun and read the thermometer—this would give too small a result, because the instrument as soon as it is warmed commences to radiate the heat away again, like any other hot body; and we would like, if we could, to keep all this heat in it to measure. As we cannot, we reach the same result by finding how much is

lost, and allowing for it. Thus, the observer first leaves the apparatus in the shade (for instance) five minutes, and notices whether it loses or gains from its own radiation to surrounding objects. Then he leaves it directed to the sun, which shines full on it for five minutes more, the thermometer being read at the end of this exposure; and finally, at the end of another five minutes, during which the instrument has been left in the shade, it is read again. The half sum of the losses or gains in the shade is the radiation, and this added to or subtracted from the apparent gain in the sunshine is the actual number of degrees that the temperature of the water would have been raised, had all the solar heat been retained. Measuring in this way, we are independent of the temperature of surrounding objects.

Mr. Ericsson, the celebrated engineer, who has improved on Pouillet's apparatus, has in fact shown that we do in accurate experimenting always get more heat (other things being equal) on a day in winter than in summer, as we should, if it is the direct solar radiation alone we are after; for that will be the greatest when the sun is nearest, as it is in our northern winter. Again, measuring when the sun is high, and at all altitudes down to the horizon, we find less and less heat, as the rays go through more of our atmosphere, and hence we can make a table showing how much this absorbs for every altitude, and consequently how much we should gain if it were taken away altogether. When this is done we find, according to Mr. Ericsson's late determinations (which we substitute for Pouillet's), that the direct heat of the sun on 1 square foot in March is competent to raise 7·11 pounds of water 1° Fah. in one·minute. This is what it would do if we got outside of our atmosphere; but owing to the absorbing action of this, the radiation which actually reaches us, under a vertical sun, will so heat only about 5·6 pounds. According to the mechanical theory of heat this effect is that which would be required to drive an engine of $\frac{5\cdot6 \times 772}{3300} = 0\cdot131$ horse power. In other words, the heat of a vertical sun after absorption by our atmosphere represents rather over one horse power to each square yard. It is true that we cannot always have a vertical sun, nor clear sky, nor can we realize in actual work this whole effect by any form of engine, but when we have made the largest deductions, the statement of the sun's power, in this form, is calculated to excite astonishment. We have here, since there are 5,280 linear feet in a mile, $5280^2 \times 0\cdot131 = 3,650,000$ horse power to the square mile (in round numbers); so that if we suppose in actual practice one horse power realizable to ten square yards, the efficient working power of sunlight on an area much smaller than such a region, for instance, as the Adirondacks, is much greater than that of the computed actual steam power of the whole world. Upon the surface of the whole earth the heat at any time must be equal to that falling vertically on one of its great circles, which contain, roughly, about 50,000,000 square miles. Here, when we come to multiply the number of miles by the power per mile, we reach figures bewildering in their magnitude, but which are demonstrably correct. The only way this heat is utilized by conversion into power at present (steam power being dependent on coal made by the sun in past times) is by windmills and waterwheels, both supplied by the sun, as in fact in every form of power, unless we except the insignificant one of tide mills, a kind only in a very remote degree dependent on solar action.

The student must be referred for the more indirect but equally certain action of the sun in providing the coal by which our engines are driven to special treatises (the popular one on "Heat" by Tyndall is a good introduction to the subject for the general reader), but this stock of coal is by no means unlimited, and in the course of a few centuries at most it will be exhausted in Great Britain, for instance, at the present rate of consumption. We may depend that long ere that time her engineers will, with those of other countries, be turning to the immense source of power in the sun's direct rays, and that regions now barren under a tropical sun, where there is no fuel, water, or scarcely human life, will rise into new importance as the proper seats of industry, fed by the new power.

Engineers have hitherto done little for this, but we may be sure they will in the future do more. We are not writing a historical article, and, merely mentioning the curious fact that Solomon de Caus, the unhappy man of genius whose connection with the history of the steam engine is so well known, was one of the first to invent a solar engine, we pass over much that is historically interesting, to come to the present. Mr. Ericsson, whose work we have already quoted, is understood to have given a large part of his life, and particularly of his late years, to the problem. Fig. 32 is a drawing of a solar hot air engine of his invention, which is said to make 400 revolutions per minute. This is probably to be considered rather as an illustration of the feasibility of the instantaneous conversion of solar heat into power than as a useful form in practice, the circular mirror not being adapted for work on a large scale. The inventor, however, at present has not published the dispositions he is understood to have made for concentrating the heat in a larger working engine.

In France, M. Mouchot has, for many years, been pursuing similar studies; a section of one of his machines is shown in Fig. 33. This has the inconvenience of a very large heat reflector in a form which is expensive and liable to injury, but it must be remembered we are now feeling our way in the first steps of invention in his new field. Such things are, in one sense, but mechanical toys at present; but it was such toys as Hero's æolipile which preceded the steam engine. These are already more than mere toys, however, and in their promise, if not in actual performance, worth attention. If the reader wishes to know what is the best so far realized, or at least so far made public, we may refer to the Comptes Rendus of the French Academy of Sciences for October 4, 1875, where M. Mouchot states that he now employs a metallic mirror with a linear focus, in which focus is the elongated boiler he uses, and that he also makes use of a glass cover to let the solar radiation pass, but to retain the obscure heat re-radiated from the boiler. In the largest machine actually built, he employs, however, a mirror in the form of a truncated cone, Fig. 33, about 10 feet in diameter at its large, and 40 inches at its small section, looking like a mammoth lamp shade, with its concavity directed skyward. The material is copper, coated inside with silver leaf. A large bell glass covers the boiler, which is about 32 inches long. The whole apparatus can be made to follow the sun. On May 20, in ordinary weather, 20 liters of water at 20° C. were let into the boiler at 8:30 h., and rose to 121° (two atmospheres) in 40 minutes, and then rapidly to 5 atmospheres, beyond which, owing to the slight nature of the apparatus, it was not thought safe to go. On the 22d July, at about 1 o'clock, under uncommon heat, the apparatus vaporized 5 liters of water per hour. The inventor claims that under

favoring circumstances, he actually realizes about 10 calories per minute per meter, which is a trifle less than one horse power to ten feet square. Something exceeding this might probably be reached with the same apparatus in a drier air; upon the whole we are justified in speaking of one horse power to the square of ten feet on the side, as actually realized; one horse power to one square yard being about the limit of that which is theoretically realizable.

It must be remembered that, according to what has been stated, the sun offers us a source of power which is practically infinite both in amount and duration. According to what we believe we know with assurance, we can say that the sun is not a fire, fed by any fuel, but a glowing gas ball, maintained at an enormous temperature, and radiating enormous heat from a fund of energy maintained by the contraction of its volume, and by the impact of meteoric bodies. We can reckon with confidence that there will be no material diminution of its supply from these sources for a duration only to be reckoned by hundreds of thousands of years. As to the amount of heat supplied, it is inconceivable. The writer has made a computation of the time all the coal of the world would suffice to maintain the sun's radiation, were the actual source of it to fail, and were our whole supply of coal transported to its surface and burned there in its place. The result, otherwise stated, is that in any one second the sun radiates into space an amount greater than could be made good by totally consuming all the known coal beds of the world!

Something like 300 years separates the England of to-day, with her countless furnaces and engines, from the England of Elizabeth, in whose reign the spinning wheel was almost the most intricate piece of machinery on the island. Something like 300 years more, it is said, is all that separates the England of to-day from the future England whose furnace fires will have died out with the flame of the last bushel of coal under her surface; whose harbors send out only sailing craft; whose manufacturing population has gone to other lands, and whose "black country" is growing green again as nature covers the ashes of her burnt-out mineral wealth with new verdure for the few who remain on the soil. We do not pretend ourselves to join in such pessimist views, or try to look into the future so far, though this is a very little way compared with what we know of the rise of man to civilization. To us, in this country, such a time, if it is ever to come, is immensely distant. But what is certain is that if some such change do not take place it will be through the discovery of a new source of power, for of the old, the coal, when our underground supply is used up we cannot get any more. Let us remember, then, in time, that though the stock be great there is no renewal.

For a journal counting among its readers so many interested in the applications of power as the SCIENTIFIC AMERICAN, I have thought, elementary as this presentation of the sun's claim to interest, merely as a source of mechanical power, is, it is better to offer it. We are, in closing, led back to the suggestion with which these articles began, of the sun's influence in altering the conditions of existence for the human race.

Future ages, it has been truly enough observed, may see the seat of empire transferred to regions of the earth now barren and desolated under intense solar heat—countries which, for that very cause, will not improbably become the seat of mechanical and thence of political power. Whoever finds the way to make industrially useful the vast sun power now wasted on the deserts of North Africa, or the shores of the Red Sea, will effect a greater change in men's affairs than any conqueror in history has done, for he will once more people those waste places with the life that swarmed there in the best days of Carthage and of old Egypt, but under another civilization, where man no longer worships the sun as his god, but has learned to make it his servant.

MARS.

IF the two great leaders of the planetary system have filled us with astonishment at their magnitude and velocity, and with perplexity in the contemplation of arrangements so incomprehensibly unlike our own, they have not exhausted all the resources of the season. There yet remains a much nearer and more intelligible neighbor, who possesses a peculiar interest for an opposite reason—his similarity to ourselves. This especial character of the ruddy planet has long been known to astronomers, and will naturally make him an object of careful study before we leave him too far behind; and though the opposition of this year does not diminish his distance so much as that of 1877, yet his almost startling brilliancy has been alone enough to prove it among the favorable ones; for English astronomers, at least, it is far more propitious than the last, from his greatly-increased elevation. Much had been expected at that last opposition from the broad expansion of his disk, but the indistinctness of detail was a general source of disappointment here, though the success of Schiaparelli at Milan and Green at Madeira showed that the fault lay chiefly—perhaps not exclusively—in the English sky. My own impression certainly then was that, besides the want of clear outline inseparable from so low an altitude, there was a deficiency in decidedness of form and strength of tone as compared with previous observations, the cause of which may have lain in the atmosphere of the planet, affected possibly by especial proximity to the sun in an orbit of considerable eccentricity. At any rate, we may reasonably hope to find the present season more favorable for exploration than the last; for though at nearest approach we have only had 28″ of disk instead of 29·4″ in 1877, success depends, with equal instrumental sharpness, much more upon altitude and steadiness of air than on increase of visible surface. Schiaparelli was enabled to obtain his most valuable results after opposition, when the diameter had decreased to 20″ or even 16″, and he asserts that he was able to continue his researches with advantage even till it came down to less than 6″.

We have alluded to the special interest of this planet arising from its supposed close correspondence with the earth, and it may not be out of place on this occasion if we bestow a little pains in examining the ground of that supposition. This we may conveniently do by imagining what would be the telescopic aspect of our own globe at a distance not equal to that of Mars, as we should then appear about twice as large, but such as to reduce our apparent diameter to equality with his in a favorable opposition.

There is every reason to believe that our surface would then appear mapped out by a distinct separation into oceans and continents, the fluid being darker than the solid masses, and preserving their bluish-green tinge but little affected by distance. Except in very shallow parts, their darkness would be uniform from the rapid absorption of incident light, and their contour would be sharply defined.

The general hue of the land would be lighter; and at a distance where its variegated patches of color would be separately undistinguishable, the result would be a gray resulting from the mixture of many tints, except where tracts, such as the great deserts or prairies, might subtend a sufficient angle to preserve their natural hue, or where extensive forests might rival seas in depth of tone. In many places, too, brilliant streaks and patches would show where mountain masses were capped with dense clouds, or surpassed the level of perpetual snow; but our largest rivers, except possibly at some great embouchure, would be totally imperceptible.

Such, in its general lineaments, would be the distant aspect of our globe, if the whole lay at once distinctly before the eye. But this would never be the case. The formation and transference of masses of vapor would produce incessant and most uncertain changes. In some regions, and at certain times of the year there would be unbroken clearness; in other tracts the outlines and coloring of land and sea would be indistinct or concealed, at times for short, but occasionally for very lengthened periods. And the interposition would doubtless be always of a white aspect, since such is the character of our clouds wherever they are illuminated by the ·sun. Toward our polar regions this whiteness would be permanent, in the form of great spots, eccentric as regards the axis of rotation, increasing through and after the winter, with a corresponding diminution after the summer solstice. There would always be, however, a large unmelted area, even at the warmest period, and its outlines would probably be often irregular and extended from the presence of great masses of frozen clouds. Now, if these would be the probable features of the earth, presented to us at a distance of seventy or eighty millions of miles, in what respects shall we be able to trace the resemblance on Mars? We are soon brought to the conclusion that, according to the general rule already referred to, there is more analogical than identical correspondence; the inclination of axis, the eccentricity of orbit, the duration of day and night, the respective length of the seasons—from the relative similarity but not identity in these particulars, we are prepared to meet with the same kind of proportion throughout. As far as aspect goes, a solid and fluid condition may be thought to divide each superfices; but if so, the land there is in a much larger ratio to the water; and if the color of our oceans is repeated on Mars, we have little to correspond with the orange-yellow tinge, which, since it leaves unaffected the polar snows, cannot arise from atmospheric absorption. The so-called seas, too, though in some places apparently deep and dark, frequently shoal off and show subaqueous markings in a way that perhaps would be scarcely paralleled in our own.

In atmospheric conditions, indeed, we find great approach to identity; yet even here there are discrepancies; the polar snows of the earth would probably not be distinguishable from the upper surfaces of terrestrial clouds floating in any latitude, while on Mars, such peculiar whiteness, though sometimes vividly brought out in certain localities, is by no means universally concurrent with the local indistinctness and confusion that so often puzzle the areographer. The action of solar heat on the polar deposit seems identical, and yet it may be a question whether our arctic snows are marked out by as regular a contour as those of Mars, and still less would they show what has often been observed there—a strongly-marked border of darkness. And however striking and suggestive may be the fact that in either globe the thermal axis is not that of rotation, we have the discrepancy that on Mars the glaciation is reduced in a much greater ratio, so that the pole, according to Schiaparelli, was in 1877, entirely free. This observer, who is fully impressed with the terrestrial theory, admits that the vertical sunlight, instead of producing clouds, as on the earth, appears to clear the sky of Mars, and thinks the atmospheric change there of a more simple nature. That the southern hemisphere would be subject to greater extremes of temperature than the opposite, as shown by the variation in size of the white caps, might have been expected as a direct consequence of the elliptical form of its orbit greatly surpassing our own.

A passing reference will be sufficient to the brighter zone, which, according to some observers, distinguishes the edge of the disk, but which others, including myself, have never detected; or to the bluish or greenish patches sometimes noticed on the limb. Such appearances may be mere results of contrast; at any rate they may be left on one side as not directly affecting our present comparison. But there is one consideration which cannot be thus disposed of, and which, obvious as it is, seems to have been taken little into account— the very different amount of solar radiation on the two planets. The heat derived from the sun on Mars is only from $\frac{1}{3}$ to $\frac{1}{2}$ of that received by ourselves. And thus we seem reduced to the alternative of either abandoning to a considerable extent the supposed closeness of resemblance in material and constitution, or of maintaining it by the hypothesis of a supply of heat on Mars derived in some other way. No ice such as ours would be so reduced by the unaided action of that distant sun—no terrestrial continents could remain so long unclothed with snow. The dilemma is a curious one. It may not be incapable of explanation, but it certainly requires more special and careful consideration than it has yet received.

We have been looking at the subject much as though a supposed view of the earth at a suitable distance might be fairly paralleled with a corresponding representation of Mars, as drawn by the best observers. But it must be added, with much regret, that such is not yet the case. As to certain main features of that planet, there is indeed a very satisfactory agreement; but with regard to others, and as to details in general, we feel, as a first impression, some extent of disappointment. It may be fairly admitted that the disk is, after all, not large, and its markings often feeble; and there is great diversity in instruments, and eyes and hands, and aptitude for the work. Yet still an exhaustive survey, of which we cannot even indicate the materials in this place, but which we trust will be carried on, as it has been most ably commenced, by Dr. Terby, of Louvain, would show much unexplained, and some things unsatisfactory. Mädler laid the foundation of definite areography; but his successors, while enlarging, have not always confirmed his results; and, to say nothing of others who have bestowed much pains upon the subject with more or less mutual agreement, our own keen-eyed and accomplished Dawes—at least as represented by Proctor—is found to differ in some parts materially from Lockyer, Kaiser, and Secchi. At the last opposition in 1877, the subject was taken in hand with especial zeal and perseverance by Schiaparelli at Milan with an exquisitely sharp Merz object glass of 7·15 inches aperture and 10 feet 8 inches focus, and by Green, who went out purposely to Madeira with a 13-inch mirror by With, the perfect polish and critical

definition of which are sufficiently guaranteed by the maker's name. Each did his best; each was far in advance of the other observers of the season; and yet at first sight there is more apparent difference in their results than might have been expected. It is not surprising that in the case of minute details each should have caught something peculiarly his own; but there is a general want of resemblance not easily explained till, on careful comparison, we find that much may be due to the different mode of viewing the same objects, to the different training of the observers, and to the different principles on which the delineation was undertaken. Green, an accomplished master of form and color, has given a portraiture the resemblance of which as a whole commends itself to every eye familiar with the original. The Italian professor, on the other hand, inconvenienced by color blindness, but of micrometric vision, commenced by actual measurement of sixty-two fundamental points, and carrying on his work with most commendable pertinacity, has plotted a sharply outlined chart, which, whatever may be its fidelity, no one would at first imagine to be intended as a representation of Mars. His style is as unpleasantly conventional as that of Green indicates the pencil of an artist; the one has produced a picture, the other a plan. The discordance arising from such opposite modes of treatment would naturally be less real than apparent; still, a good deal remains that it is not easy to harmonize. Let us hope that during the present favorable opportunity much may be effected toward clearing up the obscurities that still rest upon the study of Mars. Every contribution may prove of use, provided it is the result of that conscientious spirit that will show only what it sees, and take care to show it well.

A suggestion may be permitted that observations in the twilight might obviate the unpleasant glare arising from the vivid light of the disk, or that a screen-glass might be advantageously employed for the same purpose at a later hour.

Meanwhile the nomenclature of the spots—a point of increasing importance for identification—is in a state of pitiable confusion. This ought to be remedied at once; and its revision could be more suitably intrusted to no one than to Dr. Terby, who so thoroughly knows its difficulties, and is so competent to decide upon some system that may be adopted with the general concurrence of observers.

With regard to the satellites, we have entered into so much detail about the primary that little space remains for them. Yet we must express our hope that, once discovered, they may be more easily caught in our larger instruments, and that the magnificent reflector of Mr. Common may, as is very possible, increase their recognized number. Those already discovered are certainly among the most wonderful objects in the whole solar system. So disproportionally minute, according to our limited ideas of proportion, so speedy in their revolution that the innermost rises in the west and sets in the east, and compasses the whole heavens more than three times in a Martial day, so close that the same attendant ranges at less than 4,000 miles from the surface of his primary; so much of their time invisible in total eclipse, so powerless to influence any fluid mass beneath them, one might call them exceptions while yet they are among the strongest illustrations of the great principle of identity of character combined with the extremest variety in detail, in the inscrutable work of the Creator.—*T. W. Webb, in Nature.*

THE EARTH FIVE HUNDRED MILLION YEARS OLD.

In one of his recent lectures, Professor Proctor showed the immensity of time, past and future, as revealed by astronomy. The first general topic considered was the age of the earth. From the different geological features of the earth's surface, it has been calculated that 100,000,000 years have been consumed in the formation of its crust. Such is the estimate formed by Crowe and accepted by Sir Charles Lyell. Taking up the investigations of physicists on this subject, and from experiments by Bischaff, it is found that the time during which the earth was cooling from a temperature of 2,000° to 200°, some 350,000,000 years must have elapsed. And then prior to this again, there was a long period of time when the earth was in a nebulous condition; so that a fair estimate of the world's age may be placed at 500,000,000 years. This is considered as erring rather to the side of deficiency than to that of excess. Notwithstanding this enormous lapse of time, the speaker spoke of the earth as being one of the most short-lived of the planets. Comparing it with Jupiter, on the principle that the larger a body is, so its period of cooling will be prolonged, it is calculated that it will be 3,500,000,000 years before the larger planet reaches the stage at which our earth is. Ten times as long must pass before the sun reaches a similar condition. As for the moon, it is but 420,000,000 years since she was in this relative period of her existence. The earth will, in 1,000,000,000 years, reach the same stage of planetary decrepitude as is at present manifested by the moon.

The nebular hypothesis of Laplace was then explained. Originally all the system was star-drift, and then a dense gaseous mass, which, assuming the shape of a huge disk, began to whirl about its center. As the motion increased and the mass concentrated, a ring of matter was thrown off at the outer edge. This ring in course of time broke up into fragments. After a while these fragments aggregated into one body, and thus the outermost planet was formed. In the same way the inner planets took their shape; ultimately the great mass in the center formed the sun, around which the entire system revolved.

Similarly, in the revolutions of the as yet nebulous planets, their satellites were thrown off. The asteroids may be considered as fragments which, for some cause or other, never aggregated together; perhaps they were thrown off and too widely separated to come together again. Laplace, however, seems to have overlooked one agency in the formation of the world, and that is the meteoric showers. Some 400,000,000 of these fall during each year, and about 10,000 tons of this material are annually accumulated by the earth; but, in comparison to its bulk, this is but a trifling addition. In the past it is probable that the meteoric showers were both greater and of more frequent occurrence. By the combination of the nebular hypothesis and the theory of meteoric aggregation, Professor Proctor thought that the earth's formation was accounted for. Thus, in the countless ages of time past, we and our surroundings are but particles of the same matter that then drifted through the enormous distances of the infinite space.

The ages of the planets was next taken up. Jupiter, Saturn, Uranus, and Neptune represent a later formation than do those planets nearer the sun. The two former planets, so similar in many respects, are hundreds of millions of years younger than the earth. The rings of Saturn, it is presumed, will, in time, break and become condensed into

satellites. Jupiter is surrounded by great masses of clouds of a very light density, far within which the real planet is supposed to exist. Coming to the planets nearer by, the moon, with its deep chasms and its great mountains, was described. The dark plains, once supposed to be seas, are in reality the beds of former oceans now absorbed by the lunar crust. The intense blackness of the shadows cast by the moon are indicative of the absence of any atmosphere that it might possess.

If any planet is of the same, or nearly the same, age as the earth, it is Venus. Mars is older. Mercury is a great deal older still, and the oldest of all her companion planets, the moon. He said that Venus has an atmosphere about as dense as the atmosphere of the earth, and must have a large water service. Mars has about an equal area of land and water, and must have an atmosphere. The moon represents what the earth will be in the future. It has neither water, clouds, nor atmosphere. But, as the earth is eighty-one times larger than the moon, while it has thirteen times as much surface, it will require about 2,550,000,000 years for the earth to arrive at the present condition of the moon. Following out this theory, we greatly reduce the number of planets on which it is possible for life to exist. In our solar system we have only the earth, possibly Venus, and, it may be, some of the satellites.

THE DIAMOND—ITS ORIGIN, ARTIFICIAL PRODUCTION, AND USES.*

By HENRY A. MOTT, Jr., Ph.D., etc.

It will be necessary, for the proper consideration of this subject, to study the matrix in which the diamond occurs, when we will be better able to arrive at a theory as to its origin, and methods for its artificial production. The usual matrix of the diamond is an alluvial material, consisting chiefly of sandstone and rolled quartz pebbles, from which the diamond is extracted by careful sifting and washing. Itacolumite sandstone (a secondary red sandstone) is a solid matrix of the diamond in Brazil; this was pointed out first by M. Claussen. Prof. Leonhard † has shown that xanthophyllite shares with itacolumite in being the solid matrix of the diamond. This mineral is found in the Ural mountains. A microscopic examination of the laminæ of this mineral reveals (when obtained from certain localities) a large number of minute crystals of the diamond. These crystals have been demonstrated to be diamonds by G. Rose; ‡ they appear in hexakistehedrons, parallel to the cleavage of the zanthophyllite. Von Helmersen § separates the diamonds from this mineral by treating the same with acids.

The mineral zanthophyllite is a micaceous substance occurring with magnetic iron in talcose slates. Mr. John Paterson says the marl soil (as he calls it) is the true matrix soil of the diamond in South Africa. This marl soil he considers to be the metamorphosed carboniferous shales of the country, and the changes which have worked upon these shales, by which they have been transformed from the black carboniferous shale to the whitish ashy marl in which the diamonds are found, he attributes to intrusion of queenstone trap, which traverses the country from N.E. to S.W., in continually reoccurring dikes. The African fields seem to date from the Triassic epoch. In the strata are found the remains of crocodiles, dinosaurians, labyrinthodontes, and other monsters, as also numerous fossil plants and much fossil wood, which have been pointed out by Prof. Morris.‖ A French writer ¶ takes the ground that the diamonds of the Cape of Good Hope were originally components of aerolites which fell there and were scattered over a great distance in certain definite directions. This view is largely based upon the asserted fact that these objects occur on the summits of the highest mountains and in the plains, but very rarely, if ever, at great depths.

This is perfectly erroneous; as, at the Colesberg diamond mines, the mining has been carried to the depth of 200 ft. without any appreciable decrease in yield. More of these diamonds check, flaw, and explode, than of those obtained at the surface, and, it is supposed, on drifts. The law of natural selection has already acted on the sensitive ones, allowing only those to remain that could withstand light and atmospheric conditions. According to M. Denis there are thirty-four minerals found with the diamond, consisting chiefly of sulphurets, carbonates, oxides, silicates, and native metals.

THE ORIGINAL FORMATION OF THE DIAMOND.

To establish a theory as to the formation of the diamond, it becomes necessary to find out its composition. It is amusing to note, even as late as the middle of the eighteenth century, the definition of its composition given in a standard work on physics, which was "the purest and finest *earth*, the most ethereal *fire*, and the most limpid *water*." The first important fact relative to the nature of the diamond was established by Boyle, about the middle of the seventeenth century. He showed that, under the influence of a great heat, the diamond disappeared. A little later (1694) the Florentine academicians burned a diamond before Cosmo III., Grand Duke of Tuscany, by the intense heat of the sun's rays, concentrated by a large burning-glass or lens. Humphry Davy in England, and Lavoisier in France, first solved the problem as to its composition, which was afterward made complete by the investigations of MM. Dumas and Stass. They showed the diamond to be composed of carbon in a crystalline condition, and nothing else. This is true of exceptional crystals, but most crystals, especially if colored, leave an ash when the diamond is burned. The ash is yellow, and contains silica and oxide of iron; it is generally in the form of a cellular network, which fact may some time help to determine its origin. The crystalline colorless diamonds give about 0·01 per cent. of ash. In the colored varieties the proportion is larger, the black diamond giving 2 to 3 per cent., the ash of black diamonds resembling that of vegetable fuels. Diamonds sometimes inclose other crystals. Hartwig has noticed iron pyrites in it. Dr. Nello Franco mentions a diamond inclosing a gold leaf, and he says, "the gold leaf is seen as if not embedded in the diamond at all." The diamond incloses cavities, some of which contain gas, and others liquid carbonic acid. This last fact was arrived at by Prof. Simmler.** of Switzerland. Brewster found the liquid in some cases to have a refractive power less, but its expansive power greater, than water.

In comparing the results made by Brewster with those calculated for other liquids, Simmler found the numbers

for the expansive and refractive power of the liquid to coincide with those for liquefied carbonic acid. Other observers have concluded that some of the cavities contain another liquid—one behaving toward heat and light like water, and the other like liquid carbonic acid; but this is evidently erroneous.

Besides the diamond containing other minerals at times, it also contains sometimes germs of plants and fragments of vegetation. Prof. Goppert* states, in 1868, that he had a diamond which contained *dendrites*, such as occur on minerals of aqueous origin; that there are at Berlin one which contains bodies resembling *Protococcus pluviales*, and another green corpuscles linked together, closely resembling *Palmoglæa macrococca*. To these supposed algæ the names have been given *P adamantinus* and *Palmoglutes adamantijus*. As illustrating the view he takes of these diamonds, he says: "The metamorphic rocks in which they occur also contain evidences of fossils (vegetable) such as *Eozoon canadense;* and that even in some topazes there are traces of organic substance.

Prof. Goppert † further remarks, with respect to these foreign bodies inclosed in the diamond, while they cannot be said to be evidently and undoubtedly vegetable in their origin, it would, on the other hand, be difficult to deny their vegetable nature altogether.

The black specks in diamonds, Messrs. Sorby and Baker (such, *e. g.*, as those seen in their Cudgegong minerals) are crystals which are sometimes surrounded by contraction cracks, a black cross appearing under polarized light.

In the face of all these facts, what is the most reasonable theory as to the origin of the diamond? The Indians believe diamonds are continually regenerating and growing to this date, and the inhabitants of Pharrah in Hindostan affirm that the quantity of diamonds by no means decreases, but, on the contrary, the soil will yield a new supply fifteen or twenty years from the time it is exhausted. Mr. Norman Taylor‡ and many others also think the diamond is a product of chemical forces now in operation; and therefore it is strictly a local and limited product, not necessarily connected with any carboniferous beds of comparatively high antiquity.

As magnesite exists in the vicinity, and that is certainly a recent product, arising from the decomposition of the exposed igneous rocks; so, infiltration, decomposition, and reconstruction of carbonaceous materials of whatever age, under the influence of chemical transformation, may be producing diamonds at this moment, wherever the needful conditions exist. The question is whether the diamond had an igneous origin or not. Clark‡ says: "I was struck, when examining the sand in which the Cudgegong diamonds are found, with the amount of minute gems, such as zircon, topaz, sapphire, corundum, spinel, pleonate, etc., which composed the finest sifted materials, in which gold is also found; and Mr. Taylor not only dwells upon the circumstance that the diamond is not only associated with gold (as in most other foreign localities), but with those gems which are held to have had an igneous origin, occurring as they do in rocks which are so denominated, and in some cases (I may add) in true lava of modern volcanoes." M. Favre shows that, of the thirty-four minerals found with the diamond, thirty have been artificially formed; and of the thirty, twenty-nine were produced by the aid of volatile chlorides. "If this be the case," says Clark, "though one of the conditions is heat, the argument as to an igneous origin for the diamond, because it is associated with materials of igneous origin, must be abandoned or modified." Dr. Percy§ says there is nothing to show that an igneous origin can be attributed to the diamond, corundum, spinel, or other gem stories. Sir John Herschel infers, ‖ from the diamond containing well-formed filaments of iron pyrites sometimes, and from the combination of iron and carbon at high temperatures, the possibility of an igneous origin of the diamond. Sorby and Baker conclude that the diamond does not afford positive evidence of a high temperature, though not opposed to it.

Mr. Morren has proved that the diamond burns in layers; for if the combustion is arrested at any period, the special system of crystallization is still regularly displayed. This is a very important point, as Dieulafait ¶ points out, since it excludes all idea of fusion for the diamond. No heat hitherto applied suffices for the fusion or volatilization of the diamond, or indeed carbon in any of its forms; though in the intense heat of the voltaic arc, it appears to be transported mechanically from one electrode to another.

From a careful examination of the subject, I am convinced, for several reasons, that the origin of the diamond cannot be attributed to plutonic action. Newton, Brewster, and Liebig all agreed that, even with respect to the matrix of the diamond, the gneiss, itacolumite, zanthophyllite, and the metamorphic rocks in which it is found, could not have a plutonic origin.

The fact that most of the associating minerals found with diamond have been artificially produced by the aid of volatile chlorides—the fact that the diamond burns in layers and, if arrested, the special system of crystallization is still displayed—the fact that the diamond countries contain within it bodies which are apparently vegetable in their origin—the fact that these black spots disappear when the diamond is heated to redness, seems to prove, as Prof. Egleston suggests, that the temperature at which the diamond was formed was below red heat—and, lastly, the fact that the diamonds often contain cavities filled with a liquid, are quite sufficient to disprove an igneous origin to this gem. Newton conjectured that the diamond was an "unctuous substance coagulated." Jameson thought it might be a secretion from some ancient tree, like amber; and Brewster also traced it to a vegetable origin. Liebig and others have explained its origin by a slow process of decomposition in a fluid rich in carbon and hydrogen. Dana** states that the diamond has probably proceeded, like mineral coal and oil, from the slow decomposition of vegetable material, or even from animal matters, either source affording the requisite carbon; but it has been under those conditions as to heat that has produced the metamorphism of argillaceous and arenaceous schists and their auriferous quartz veins, since it is found exclusively in gold regions or in the sands derived from goldbearing rocks. The schists that were altered at the time may have been previously shales, impregnated with petroleum or other carbonaceous substances (hydrocarburets) of organic origin.

* Read before the New York Academy of Sciences, January 19, 1880.
† Das Ausland, Augsburg, June 26, 1870, p. 621.
‡ Am. Chem., vol. 2, p. 429.
§ The Academy, Jan. 1, 1872, p. 15.
‖ Communication to the Geol. Soc. of London. The Academy, Dec. 1870, p. 70.
¶ Les Mondes, Paris, Dec. 14, 1871, p. 601.
** Sci. Am., Oct. 7, 1868.

* "On the Organic Nature of the Diamond."
† Seemann's Jour. of Botany, 1864.
‡ Article "On the Origin of the Diamond," by Rev. W. B. Clark, Chem. News, 607, 1871.
§ Lecture on Chem. Geol., Dec. 12, 1865.
‖ Physical Geography.
¶ "Diamonds and Precious Stones," Louis Dieulafait, 1876, p. 83.
** "Mineralogy," article "Diamond."

Chaucourtois suggests that, in the humid oxidation of a carbureted hydrogen, the hydrogen would be oxidized; part of the carbon would be changed to carbonic acid, and the rest he supposes would remain as carbon, and might form crystallized diamonds. Prof. Simmler, a few years ago, offered a new theory to explain the origin of the diamond, and it is to me a very reasonable one, and one which a few experiments I hope soon to make will settle as to its worth. He supposes that carbon is soluble in liquid carbonic acid, which, on slow evaporation, would permit the dissolved carbon to separate out in crystals. In evaporating quickly, the black diamond would be formed. It is thought probable that liquid carbonic acid may form in the interior of the earth. In the gaseous form it is evolved from fissures, volcanoes, and mineral springs. When, now, this gas is produced in the cavity of a rock which is free from fissures, it will finally be compressed so highly that it will assume a liquid form. Certain rocks may be considered strong enough to resist the expansive force of this agent. Let, now, carbon be present. If the same is soluble, it will be taken up and deposited again, while the carbonic acid is escaping as gas through some newly-formed cracks or fissures.[*] Another theory has been advanced: that perhaps the carbonic acid gas which forms in the earth by some peculiar process, becomes deprived of its oxygen, and leaves the carbon behind to crystallization.

In favor of this view I can state that, in all attempts to produce the electric light between two carbon points in a partial vacuum, the oxygen present is not only satisfied in forming carbonic acid gas once, but actually by some peculiar process deposits its carbon on the sides of the globe containing it, and goes back and oxidizes more carbon, and this process goes on indefinitely. Some such process might possibly be going on in nature, or have taken place, with the exception that the carbon separated out so slowly and continually that crystals formed.

Just the opposite to this took place in some experiments with the diamond conducted by E. H. Von Baumhauer. He heated a diamond to whiteness in an atmosphere of dry carbonic acid, when the diamond became dull on the surface and lost in weight, hence it must have decomposed the carbonic acid gas, and united with its oxygen. This is, of course, a very exceptional action for an element to make; and one writer has offered as a theory that the diamond might be an allotropic modification of carbon, like ozone is of oxygen. I think the first theory relating to liquid carbonic acid is the most probable, for it would not be difficult to understand how this liquid could take up vegetable matter—crystals and gold—and leave them in the diamonds formed, and an explanation of the liquid carbonic acid in the diamond is at once understood. Prof. Clark[†] says: "If the diamond were derived from carboniferous rocks, why are they not found in the river bed, except where the tailings of the miners have been washed in? From all the evidence arrived at, the newer drift is derived from the older, and with them is associated a cement of quartz and altered rock, held by a yellowish green silicate of iron and hydroxide of iron, from hand specimens of which I have myself taken gold. Mr. Taylor says it contains diamonds also."

THE ARTIFICIAL PRODUCTION OF DIAMONDS.

The first experiments on record to produce the diamond by artificial means were made by Cagniad de Latour and J. N. Gaunal, in 1828. Cagniad de Latour sent to the Academy of Sciences ten tubes containing brown crystals, some of which were of considerable dimensions. They were brilliant, transparent, and harder than quartz. They were carefully examined by M M. Thenard and Dumas, who showed them to be merely silicates or artificial precious stones. The process adopted by Gaunal to produce his diamonds was as follows: he took equal weights of carbon sulphide and phosphorus, both as pure as possible, and put them in a flask, pouring on top a little water to prevent the sulphide from turning to vapor and from taking fire. The whole was placed in some situation where it would not be disturbed. The sulphur of the sulphide combined with the phosphorus and released carbon, which fell to the bottom and assumed a crystalline form.

This result took place slowly and not until the loss of six months even diamonds were obtained the size of a grain of millet seed. The experiment was repeated many times by Gaunal with the same results. The carbon consisted of pure carbon in dodecahedral crystals, and they scratched steel like the natural diamond. M. Champigny examined these diamonds with care, and pronounced them to be. Dieulafait says the opinion expressed by Champigny was perfectly erroneous. Whether this is so or not it is difficult to answer. M. Despretz was the next experimenter: he endeavored to produce the diamond by igneous means. He secured and united all the Bunsen piles that he could procure in Paris, and so obtained a very powerful current, and he then submitted carbon to the action of the intense heat. The carbon was molecularly dissociated and deposited in the form of fine dust on the walls of the vessel, but no diamonds were produced by this method. Having failed by the use of intense heat, he changed his system. For the current of the pile, intense and incessant, he substituted currents of induction, intermittent and feeble; and in place of continuing their action for several hours, maintained them in activity during entire months.

He made use of a glass vessel, similar to and similarly fitted up as that known as the electric egg. To the lower rod he attached a cylinder of pure carbon, an inch or so in length and nearly one-half an inch in diameter. To the upper rod he affixed a bundle of fine platinum wires. At the completion of a month, a slight black layer of carbon had been deposited on the wires. This layer viewed through a magnifying glass presented nothing very distinct, but to the compound microscope with magnifying power of about thirty diameters it offered several interesting features. Upon the wires, and especially upon their extremities, certain separate points were discoverable, which appeared to belong to the octahedral system. An experienced crystallographer confirmed this view, and recognized octahedrons, both black and white, the black being truncated at their extremities. In another experiment M. Despretz fixed a cylinder of pure carbon to the positive pole of a weak Daniell pile, and a platina wire to the other pole. The experiment lasted two months, when the negative wire or pole became covered with a black coating which M. Gaudin proved in the presence of M. Despretz, when mixed with oil, sufficed to polish several rubies. The black powder deposited in the water served to give a similar polish, but required a longer time. As it is known that the diamond is the only substance that polishes the ruby, both MM. Gaudin and Despretz did not hesitate to consider both these substances as the powder of

[* See Sci. Am., Oct. 7, 1866.]
[† Chem. News, 607, 1871.]

the diamond. Despretz also claims to have produced diamonds by the action of an electric current on one of the chlorides of carbon (not particularly specified). The crystals obtained were warty bodies, exhibiting shining faces, and having nearly the hardness of the diamond produced in his second experiment.

The late Dr. Hare, of Philadelphia, succeeded in melting down mahogany charcoal so as to produce a metallic appearance by his deflagration. Prof. Silliman likewise made similar experiments with plumbago, which produced small globules, some of which were so transparent that they could not be distinguished from the genuine diamond. Prof. Vanuxen, who examined the globules obtained from charcoal, found them to contain iron and carbon, which led him to the conclusion that the charcoal had not undergone a real fusion. M. De Chaucourtois proposed to pass a very slow current of carbureted hydrogen in a mass of sand containing putrescible matter, believing that, under the influence of the humid oxidation, all the oxygen would be transformed eventually into water; one part only of the carbon into carbonic acid; and he thought it possible that the remainder, being slowly deposited, might crystallize and form diamonds. A number of years have passed since the expression of this view, but with no positive results. Recently we heard from across the ocean that Mr. James Mac-Tear, of the St. Rollox Chemical Works of Glasgow, had, after having thought carefully over the subject from time to time, and made many abortive experiments extending over a period which dates back to 1866, succeeded in obtaining crystalline forms of carbon. These were said to be perfectly pure and transparent and have all the refractive power of diamonds, have the crystalline form of diamonds, and would resist acids and alkalies. From experiments and examinations made by several observers, they were pronounced diamonds; but Prof. Maskelyne, of the British Museum, after a careful examination, pronounces them to be silicates, and not diamonds at all. Production of crystals of carbon, as has been already shown, has been accomplished by others; so unless Mr. MacTear has discovered a process to make them of considerable dimensions, there is really nothing new except, perhaps, the process he adopts, which he has not as yet published. M. Deville and Vöchler came to the conclusion from their experiments in producing crystallized boron that the carbon contained in the crystallized boron is present there in the state of the diamond.

Some of the crystals they obtained gave the following analysis:

Boron	89·1
Aluminum	6·7
Carbon	4·2
	100·0

It would be supposed that this proportion of carbon (4 to 100) would prevent the boron from being transparent, but such is not the case; and, what is still more surprising, the boron becomes more and more transparent as the proportion of carbon increases. It is for this reason that Deville has concluded that the carbon is in the condition of diamond in the crystals of boron. That the diamond will be produced in time, I think, there can be no doubt, for substances of much more complex composition and with far more complicated crystalline constitution have been artificially produced with ease.

THE USE OF THE DIAMOND.

Besides its use for personal adornment, its uses in the arts are numerous. For cutting glass[*] no other substance equals it. A natural edge or point is used for this purpose about $\frac{1}{70}$ of a carat. It is said,[†] when a diamond is used to cut hot glass, it will only last one day, assuming a milky appearance; if the glass is cold, one will last three months. Hot glass, however, is cut more readily than cold. Diamond points are used to engrave on carnelians, amethysts, and other brilliants, and for finer cutting on cameos and seals. Being very hard, the diamond is used for the steps of pivots in chronometers. Since it possesses high refractive with inferior dispersive power and little longitudinal aberration, it has been successfully employed for the small deep lenses of single microscopes. The magnifying power of the diamond in proportion to that of plate glass ground to similar form is as 8 is to 3. For drawing minute lines on hard steel and glass, to make micrometers, there is no substitute for the diamond point. Diamonds are also employed for drill points, to perforate rubies and drill holes in draw plates for fine wire, and to drill in hard steel. Large drills containing a number of diamonds are used to drill holes in rock for blasting, to bore artesian wells, etc. The diamonds used for most of the above purposes is a modification of the diamond called "bort." These consist of translucent, but not transparent, colorless, or grayish spheroids, from which small octahedra can be split out, which are much harder than the well-crystallized diamond, but inferior to the carbonado—another modification in this point. Small, irregular, and imperfect diamonds are crushed in steel mortars, and the splinters are made into drills in many cases. Diamond dust produced by the abrasion of diamonds against each other in the process of cutting and polishing them is very valuable for polishing gems and giving the finest edge to every kind of cutlery.

Diamond dust works quicker and gives a finer edge than emery, corundum, or ground glass. The discovery of the use of diamond dust, a few years since, led certain dishonest persons to extensively advertise spurious preparations, consisting chiefly of emery powder or powdered quartz, under the name of diamond dust. As a rule, such preparations destroy the edge of cutting instruments, converting razors into saws.

The uses of the carbonado or black diamond may be summarized as follows: It is used to point edges or face tools for drilling, reaming, sawing, planing, turning, shaping, carving, engraving, and dressing flint, grindstones, whetstones, emery, corundum or tripoli wheels, iridium, nickel, enamels, crystals, glass, porcelain, china, steel, hardened or otherwise, chilled iron, copper, and other metals.

AMMONIA FROM ATMOSPHERIC AIR.

A METHOD of obtaining ammonia from nitrogen derived from atmospheric air has been patented by Wm. Müller, of Antwerp, and Edmond Geisenberger, of Brussels, and has some features of interest, and possibly of commercial value.

In carrying out their invention the patentees subject to the action of electricity in the presence of hydrogen the products of combustion, which are almost exclusively composed of nitrogen, and which may be purified so as to eliminate any foreign bodies from them. The hydrogen is obtained

[* Sci. Am., vol. 2, new series, p. 84, 1880.]
[† Pop. Sci. Rev., Oct. 1870, p. 440.]

by any suitable means. It is well known that the action of electricity sometimes decomposes gases at rest. According to the invention the gases subjected to the action of electricity for the manufacture of ammonia are put in motion with or without pressure, and the ammonia produced therefrom, as soon as it is formed, is made to pass away from the decomposing action of electricity.

The apparatus consists of a suitable retort or vessel mounted in a furnace, and containing coke or other carbon, which is heated to a red heat. Vapor of water is conducted into the retort or vessel, and hydrogen gas is evolved. The hydrogen is taken from the retort by means of a pump or other suitable apparatus, and is conducted into a reservoir in which it may be cooled or purified previously to its being conducted to the combining apparatus. The products of combustion, which consist in reality of atmospheric air that has been employed in promoting combustion, with the addition of certain products of combustion, are taken by means of a pump or other suitable apparatus from the flues of the furnace, and are conducted to a vessel containing a body (such, for example, as lime) capable of absorbing gases other than nitrogen gas. From this vessel the nitrogen is conducted to the combining apparatus.

The yield of the pumps or exhausting apparatus is calculated so as to supply the gases to the combining apparatus in the proportions required for the formation of ammonia, that is to say, three parts of hydrogen to one of nitrogen. The combining apparatus consists of a glass or other tube fitted at its upper end to a tubular or other shaped box, connected by suitable pipes with the vessel containing the hydrogen and the vessel containing the nitrogen. In the combining apparatus is a helical wheel or fan, caused to revolve by the gases as they pass into the tube. To the lower end of the glass tube is attached a valve box, to which is connected a pipe for the exit of the ammonia as soon as it is formed. In the glass tube are electric wires or conductors connected to a suitable source of electricity. The hydrogen and the nitrogen entering the combining apparatus are mixed together by the action of the helical wheel or fan, and in the glass or other tube are acted upon by electricity in the form of electric sparks or otherwise, and under the influence of the electricity they unite and form ammonia, which as soon as it is formed passes out through the valve box, and may be utilized as required.

ON A NEW VIOLET COLORING MATTER.
By M. PRUD'HOMME.

THE coloring matter recently introduced into commerce by the firm of Baeyer, of Elberfeld, under the name of "solid violet" or "anthracene violet," presents at first sight such analogies with galleine that we are naturally led to make a comparative study of the principal properties of these two bodies.

Anthracene violet (we preserve this name until better informed) presents itself in the form of a violet-brown paste like galleine or anthracene blue. The solutions of the two coloring matters in alkalies or other solvents offer on comparison shades almost identical.

Reduction with soda and zinc-powder gives in either case a yellow-brown solution. The decanted liquid, on treatment with an acid, followed by soda, takes the same brownish-red coloration.

Reduction in an acid liquid presents analogous phases of coloration.

Cloth mordanted with alumina and iron is dyed in shades which differ but little. The reds obtained with alumina have a more violet tone in the case of anthracene violet than in that of galleine. Under the influence of light this difference becomes less in consequence of a reversion, with loss of blueness, toward the red of galleine.

Soaping at a boil strips cloth mordanted with iron and alumina and dyed in galleine, whilst under the same treatment anthracene violet resists well and is brightened. This property alone may serve to distinguish between the two bodies.

Mordanted goods dyed with either color are only affected in a transient manner when passed through dilute sulphuric or muriatic acids, and the colors may be restored by alkalies.

With nitric acid both are completely destroyed.

The degradation of the shades on treatment with a solution of bleaching lime occurs in the same manner in either case, and the shades finally disappear.

Boiling lime-water in both cases turns all the shades to a very blue violet. On studying the mordants best adapted for the fixation of anthracene violet by the steaming process, it is readily found that acetate of chrome gives the best results, especially in presence of the bisulphite of soda. M. H. Koechlin has already established the same facts for galleine and coeruleine.

Steam violets obtained either with galleine or anthracene violet stand soaping at a boil.

Under certain conditions anthracene violet, fixed with acetate of chrome, may give rise to a blue. It is merely requisite to print upon cloth prepared with oil as if for turkey red a color containing, in addition to the acetate of chrome, chloride of calcium, as for instance:

Color.

Thickening	2 lb. 3 oz.
Anthracene violet	7 oz.
Acetate of chrome, at 10° B.	1–16th of 35 fluid oz.
Chloride of calcium, at 10° B.	4¼ fluid oz.
Bisulphite of soda, at 20° B.	4½ fluid oz.

Thickening.

Water	105 fluid oz.
White starch	8¾ oz.
Light calcined starch	1 lb. 1¼ oz.
Olive oil	5 oz.

Steam for 90 minutes; wash and soap for 30 minutes at 122° to 140° F. Upon cloth not oiled this same receipt gives a fine violet.

A galleine color, applied under the same conditions, gives the same results. The blue shade is certainly less pure and more violet than that from anthracene violet.

M. C. Kopp, having undertaken to examine the two coloring matters with the spectroscope, concludes that the two spectra at unequal strengths are identical, the one being merely a dilution of the other. Both, then, must belong to the same family.

A consideration of another order is added to these proofs. Anthracene violet possesses a considerable tinctorial power; samples containing five per cent. of dry coloring matter give violet shades as intense as alizarines at ten per cent.

Galleine possesses the same property, which, up to a cer-

tain point, may be considered as characteristic of this family of dyes.

We may then admit, with a very great probability, that anthracene violet is closely related with galleine, of which is is probably a substitution derivative.

One of the most important properties of galleine, that of being transformed into ceruleine by the action of sulphuric acid, is completely absent in anthracene violet, and seems lost beyond recall.

We may thus sum up the characters which distingush anthracene violet from galleine:

1. Non-transformation into ceruleine.
2. Resistance to boiling soap upon goods mordanted with iron and alumina.
3. Greater fastness on exposure to light.

The fundamental shades which anthracene violet gives with the metallic oxides are as follows:

Alumina—violet red.
Lime—violet blue.
Chrome—violet or blue, according to circumstances.
Copper—violet red.
Tin—red, like that given by alizarine with mordants of chrome.
Iron—violet.
Manganese—violet.
Nickel—dull violet.
Lead—blue violet.
Zinc—violet red.

Whatever may be the mordant employed, the shades are more blue upon cloth prepared for turkey red. The addition of bisulphite of soda improves the luster.

As in case of alizarine blue, the best results are obtained with acetate of chrome and prussiate of potash or ammonia in small proportions. The latter mordant gives darker but duller shades than the acetate of chrome.

The following color gives a curious result:

Thickening ....   2 lb. 3 oz.
Anthracene violet............   7 oz.
Red prussiate, at 10° B.....   1–16th of 35 fluid oz.
Chloride of calcium, at 15° B.,   1–16th of 35 fluid oz.

After steaming, the shade is gray (dirty) and the coloring matter as if destroyed.

On washing and soaping the violet shade quickly returns. This momentary transformation is due to the oxidizing action of the mixture of red prussiate and chloride of calcium.

If bisulphite of soda is added to the former color, which transforms the red prussiate into yellow prussiate, this change is not produced, and the shade comes up violet from the steaming.

The blue color mentioned above presents some remarkable features. Acetate of lime cannot be used in place of chloride of calcium for the preparation of this blue; it gives a violet instead.

On combining two and two acetate and chloride of chrome with acetate and chloride of calcium in varied proportions the following results are obtained:

Acetate of chrome and acetate of lime—violet.
Acetate of chrome and chloride of calcium—blue.
Chloride of chrome and acetate of lime—violet blue.
Chloride of chrome and chloride of calcium—blue.
Nitrate of lime acts like the chloride, but gives duller shades.

Under certain conditions and in presence of certain coloring matters the acetate of lime is less apt to form lakes upon the tissue than the other salts of lime.

Chlorides of barium and magnesium do not give a blue.

The blue color obtained, according to the above receipt, unfortunately does not resist the action of prolonged soaping at a boil. The oily or limy lake is gradually dissolved at this temperature, and soon there only remains upon the fiber the violet lake of oxide of chrome and of the coloring matter. This defect is much lessened by making use of a very strong oiling; and of a very pure acetate of chrome. The best acetate is that prepared by reducing chromic acid with alcohol in presence of acetic acid.

The blue thus obtained resists chlorine tolerably well and also red prussiate and alkali, which, however, turn it paler and greener. Chromic acid destroys it rapidly. As regards resistance to light it is better than alizarine blue, and may perhaps be used in the production of furniture prints with the block.

The violet shades obtained with anthracene violet are almost identical with those furnished by galleine. Without being absolutely fast they resist the action of light much better. As they are brighter than alizarine violets they may be of service.

Lastly, anthracene violet may be associated with alizarine for dyeing goods mordanted with iron for violets, in proportion to one part of the former to three of the latter. Salts of lime must be avoided in dyeing. The use of oil as for turkey reds does not seem advantageous.—*Proceedings of the Chemical Committee of the Mulhouse Society.*

FALSIFICATION OF COPPERAS.

THE copperas of commerce is always impure. The substances commonly met with are an excess of acid, subsulphate of the sesquioxide of iron; sulphates of zinc, of copper, alumina, lime, magnesia, alum, treacle, and sometimes arsenic.

It is easy to detect if sulphate of iron contains an excess of acid, as it effervesces with the carbonates in a concentrated solution.

This acid may be determined either by removing it with alcohol, which is then titrated with a standard alkaline solution (the alcohol must be absolute and the copperas free from moisture), or by determining the quantity of sulphuric acid, with a salt of baryta in the ordinary manner; 100 parts of pure copperas should give only 83·81 parts sulphate of baryta (any excess beyond this quantity is due to free acid). Persulphate of iron is detected in copperas by the precipitate of Prussian blue in a solution of the suspected sample on adding yellow prussiate, and by its red coloration with the sulpho-cyanide of potassium.

The presence of zinc in copperas is found by adding ammonia in excess to the solution, filtering and driving off the excess of ammonia from the clear liquid by heat, when oxide of zinc, if present, is deposited in flocks.

To detect manganese a small quantity is calcined with caustic potash on a slip of silver; the residue contains green "mineral chameleon," easily recognized by its color.

Sulphate of copper is chiefly found in copperas prepared with excess of acid, which, according to Pommier, may contain on an average 31 per cent. (1). The presence of copper is detected by immersing in the solution a clean knife blade, which becomes coated with copper.

The presence of alumina in copperas is rendered visible by precipitating a solution of this salt with caustic potash, an excess of which, with the aid of heat, dissolves the alumina. On adding sal-ammoniac to the clear liquid, the alumina is precipitated.

Treacle has been lately used to give the copperas a dull brownish color and a greasy feel, which foolish consumers prefer.—*Teinturier Pratique.*

[Among these impurities, none of which, save possibly the treacle, are added intentionally, the only one of general importance in English copperas is alumina —*Chemical Review.*]

CLEANING CASHMERES AND SILKS, AND DYEING WITH RESISTS.

DYERS who have to whiten a soiled cashmere, or tissues of goats'-hair which have been partly worn, often encounter serious difficulties. What means are to be employed for such an operation?

The following is the most simple process:

Dissolve in hot water a little of the best soap, adding a spoonful or two of ox-gall; stir up this bath till it froths, and steep the goods, which should have been first carefully washed. After rinsing in cold water, to which a little alum has been added to keep up the colors, and wringing carefully between two pieces of clean linen, they may be pinned out to dry in the shade.

Dyers are well aware that there are many means of cleaning, by using in turn soda-crystals, ammonia, benzol, ether, methylene, oil of turpentine, etc., to remove tarry spots. These are agents to be mistrusted, as they often alter the shades of the tissues on which they are applied. They are very useful, and give satisfaction in many cases, but they will never supersede the employment of soap and gall, especially in cleaning silks, where the utmost care must be taken.

Spots on silk may be removed by rubbing them with soaplye, always in the same direction. They are then washed in abundance of water. Before drying they are left for an hour between two pieces of white linen.

As for silks with resists (parts to be left white), grind in a mortar 4½ oz. egg albumen, and reduce it to a uniform powder. About 750 to 800 grains of pipeclay are then ground up; the whole sifted through silk and mixed with ½ oz. starch.

This mixture is then made up with the needful quantity of water and applied upon the goods with a brush. The parts to be reserved are then dusted over on both sides with powder of albumen, and a hot iron passed over to render it insoluble in the dye-beck. After dyeing, the resist may be removed by friction.—*Moniteur de la Teinture.—Chemical Review.*

THE NEW ANÆSTHETIC — THE BROMIDE. OF ETHYL.

By R. J. LEVIS, M.D., Surgeon to the Pennsylvania Hospital and to the Jefferson College Hospital.

IT is generally admitted that there are essentials of anæsthesia which are not satisfactorily attained by the anæsthetics in ordinary use. The inconveniences of ether and the dangers of chloroform have suggested further inquiry among the large number of chemical substances which are capable of producing insensibility to the impression of pain.

In April, 1879, my attention was directed to the bromide of ethyl by Dr. Laurence Turnbull, of this city, who was, I believe, the first to experiment on the human subject with its anæsthetic properties, testing it originally on himself, and afterwards on patients undergoing surgical operations, but its physiological action on some of the lower animals had been previously determined by other experimenters.

I have since that time continued to give practical attention to the subject of the anæsthetic use of the bromide of ethyl, and, whilst recognizing the fact that a very large number of administrations is essential to determine its merits comparatively with other agents, I have now had sufficient experience upon which to at least base some very decided impressions of its value.

Its principal physiological characteristics which will concern the surgeon, are the rapidity of action and the quickness of recovery from its effects.

As far as observed by me, it does not influence the circulation, excepting to sometimes produce a slight increase in the rapidity of the heart's action and in arterial tension or pressure. The cerebral anæmia and the fatal syncope of cardiac depression, to which chloroform is liable, are dangers which do not appear to threaten in the anæsthesia of the bromide of ethyl.

Respiration is but little influenced by the bromide of ethyl, as I have administered it, beyond the ordinary characteristics of all anæsthetic sleep; but in this respect its action seems more to resemble that of ether than that of chloroform. While making these assertions, I fully recognize the fact that the ultimate effects of all anæsthetics show that they are depressing agents.

Nausea and vomiting appear to occur less frequently in the anæsthesia of the bromide of ethyl than in that of ether or of chloroform, and the rapidity of recovery from its effects must render such impressions very brief and transient.

Commencing with the occasional and very cautious use of the agent, I have more recently adopted it to the exclusion of other anæsthetics, and am recording a series of detailed observations as to its effects.

Bromide of ethyl, or hydrobromic ether, is a colorless liquid, with a specific gravity a little greater than that of water. It has a decided and characteristic odor, which is thought to resemble that of chloroform, but is less agreeable. It vaporizes more readily than chloroform, and in this respect and in density is intermediate between ether and chloroform. It seems to be entirely eliminated through the lungs, and in this regard has a decided advantage as to safety over chloroform. The high vaporizing point of chloroform does not permit its rapid elimination from the body, and it is not entirely removed by the lungs. So, when some secreting organs happen to be, from disease, incapacitated, the nervous system is liable to become overwhelmed. The odor of the bromide of ethyl remains for a longer time on the breath of a patient than does that of ether or chloroform, but it seems to be quickly dissipated from the apartment in which it has been used. Its vapor is quite unirritating to the respiratory passages when inhaled, and in this quality has the advantage over both ether and chloroform.

General excitement and the tendency to struggle occur far less frequently than in the early stages of the anæsthesia of ether, and, apparently, even in that of chloroform. It is evident that the impression on the motor centers must be very rapid, and I estimate that complete anæsthesia is accomplished in one-third less time than is the case with chloroform. The recovery from its effects is even comparatively more rapid, in the greater number of cases the time not exceeding two minutes after the inhalation has ceased. Muscular co-ordination is so quickly regained that the patient is often able at once to stand and to walk on awakening from profound anæsthesia. The pupils dilate as soon as complete anæsthesia is induced, and, as the sentient state returns, they resume their normal condition. I suggest that the condition of the pupils may be an index and guide in the administration.

Anæsthesia with the bromide of ethyl is usually enacted in from two to three minutes. The most rapid production of complete insensibility, in my experience, has been in one minute, in the case of a girl eight years old; the longest period has not in any case exceeded four minutes. When carefully administered, the quantity consumed has varied from one fluid drachm in the case of a child, iridectomy being performed, to eleven drachms used during an amputation of the forearm of an adult, occupying forty minutes, including the ligation of the vessels and the dressing of the stump.

The quantity of the article consumed in effecting anæsthesia will greatly depend on the method and manner of using it. Much of it is, of course, wasted by diffusion in the atmosphere. With great regard for economy, this waste may be prevented by imperviously covering the material on which it is poured. My own plan, with adults, is to pour two drachms of the bromide of ethyl on a small napkin folded up to a space of about four inches square, and then laid on a larger napkin, folded so as to be large enough to cover the entire face of the patient. It is well to secure the two napkins together with a pin.

The vapor of the bromide of ethyl is not inflammable; indeed, when dense, it extinguishes a flame if brought into contact with it. In this respect it is free from the danger incident to ether when administered at night in proximity to lights, or when the actual cautery is used. The article used by me was made by the firm of Powers & Weightman, manufacturing chemists, of this city.

The ordinary essentials of the proper and safe production of anæsthesia are required in the use of the bromide of ethyl.

That these essential details are apt, through ignorance or carelessness, to be disregarded, every practical surgeon is aware, and the frequent difficulties and occasional calamities will attest. When it is stated that whole pints of ether or many ounces of chloroform, were used in the production of anæsthesia in a single case, he knows where was the fault. When it is asserted that "ether would not act and chloroform had to be resorted to," be knows why it "would not act."

It is becoming evident that the dread of unavoidable disasters from chloroform and the inconveniences of ether are tending to prevent their humane administration in many cases where the blessing of anæsthesia is due to the sufferer. This is particularly so in localities where etherization, simple and safe as it is, seems strangely ignored. In a prominent French hospital I not long ago witnessed the application of the actual cautery and other painful procedures without the resource of anæsthesia.

Whilst feeling inclined to impress caution in regard to the use of so powerful an agent as the bromide of ethyl, I am, from a basis of experience, inclined to recommend its use to the profession.—*Phila. Med. Times.*

THE INFLUENCE OF SHOCK ON MEMORY.

By DR. R. O. COWLING, M.D.

MENTAL depression, incoherence of thought, and absolute insensibility are of course the common symptoms accompanying shock, varying with its amount, and moments, hours, days, weeks, or even months of blank follow upon a jar of the brain, according to the degree of disturbance to which it may have been subjected. These are ordinary phenomena; but while it has been common to note the time at which the patient comes to himself and memory resumes its action, it is not so general to inquire as to what particular moment recollection vanished. I think we are generally content to date this from the time when the injury was received, and yet under some circumstances it will be found that there has been quite an appreciable period antecedent to this, of which all record has been wiped from the brain; and this fact may be of importance in several ways. Several cases in my experience, illustrating the truth of the proposition laid down, happening in swift succession, induces me to make a record of them.

I. A gentleman returning to his home one night went first to the front door to get in, but this being locked he went round the house to the back door. Alongside of this entrance were steep steps leading to an open basement, and the night being very dark he missed his way and fell into it, a distance of eight feet. When found, supposably within a half hour afterward, he was completely unconscious, and upon examination it was discovered he had a scalp wound on the back of his head down to the bone, which was unbroken. He was restored to consciousness in a few hours, and the next morning was wholly cognizant of passing events, and several days later was about as usual. He retained no memory whatever of his fall, all recollection ceasing at the time when he turned away from his front door to go around the house, though after this he had to traverse a distance of a hundred feet to reach the point at which he fell.

II. Two weeks since I attended with Dr. J. A. Brady, of this city, a gentleman who had fallen through a hatchway of a warehouse, a distance of nine feet, into a cellar. He had a rib broken and a deep wound in his chin. Within a half hour after his fall he was removed to a carriage, assisting somewhat those who were helping him. He had great confusion of thought for several hours afterward, asking continually where he was, what was the matter with him, etc. He had a sharp surgical fever, an abscess developing in his jaw; but after the first thirty-six hours his intelligence was completely restored. He had no recollection of his accident. All he remembered was that he and his brother had entered the warehouse together at dark; that he had sat down by the stove at the front door, and his brother had gone back some distance to the counting room; that when he had warmed himself he rose to follow him. The rest was blank. From the stove to the hatchway was a distance of thirty feet.

III. Within a day or two of the time at which the above-mentioned accident occurred, a man fell from the third story of the "Southern Dairy" (a "butterine manufactory"), into the cellar below, a distance of fifty feet. Saw the case an hour and a half later with Prof. T. S. Bell. The injuries sustained were a dislocation of the left ankle, with comminuted fracture of the lower end of the left tibia and

fibula, a simple fracture of the right thigh, and compound comminuted fracture of the right ankle, the tibia having apparently been driven through the sole of the foot, crushing the astragalus and os calcis. The man was in profound shock, but quite conscious of what was going on around him; refused amputation, saying he would rather die. He lived seven days, and was apparently conscious up to the time of his death. He had at least full intelligence during several days of his illness, and gave about the following account of his accident: "It was early in the morning, about seven o'clock, and quite dark. I had the truck-wagon loaded with butter, and wheeled it (shoving it) to the elevator-way, the doors of which were open. As the back wheels passed over the ledge, I found the wagon beginning to fall, and knew that the elevator was not there. In my fright I could not let go the handle of the wagon. I remember then the cold air rushing past me. I thought I had been falling a long time, and reached out my hands. Then I remember no more."

IV. On the night of December 13 a railway train on the junction track between Louisville and Great Southern and the Louisville and Cincinnati railways, passing through a suburb of the city, struck a horse attached to a wagon in which there were two men. The horse was cut loose from his attachments and killed, the wagon wrecked, and the men thrown violently to the ground. I saw them about an hour later. One of the men was nearly pulseless and quiet; the other was in great pain and violent at times, apparently bordering on delirium. I attended the cases with Dr. J. A. Larrabee. One of the men had a comminuted fracture of the right clavicle. After lying in considerable shock for several hours, reacted well, and his general condition progressed favorably. The other had a scalp wound extending into his right temple down to the bone, in which there was a fissure an inch or more in length. He had also a dislocation at the right shoulder. His shoulder being reduced and his wound dressed he became quiet; and at a visit paid twelve hours after his injury he was well at himself and continued so. He remembered nothing of the events of the night in which he was injured subsequent to the time that he "turned the corner at Meffert's," at which point his horse was trotting slowly. This was about seventy yards from the place where his horse was struck. He said also that he heard no signals (bell or whistle) from the train. His companion remembers "nothing" of the event.

V. A boy aged five was in the habit of climbing out upon a window sill, for which his mother had punished him. Entering the room one day, she saw him again in his perilous situation. Afraid to alarm him by speaking to him, she ran below to warn him back and to catch him in case he should fall. She was too late, however, finding him lying insensible on the pavement from the fall of a dozen feet. The injury sustained was apparently a fracture at the base of the skull, hemorrhage, and a serous discharge coming from his ears. He recovered, however, and his consciousness returned in forty-eight hours. His account to his mother of his fall was: "I wasn't bad, mamma. I got out on the window, but I got back before any one told me."

The comments I have to make on the cases narrated shall be brief. They are:

First.—That the point at which memory leaves off in injuries accompanied by great shock seems to be at the record of the last prominent idea. In the first case, the walk around the house was monotonous, and the gentleman was no doubt all the while occupied with the circumstances connected with his not getting in his front door as he had at first intended. In case second, the prominent idea of the man was in leaving the comfortable stove to join his brother. In case third, memory seems to have faded only a moment before or just at the strike. In case fourth, "Meffert's" was the last landmark. In case fifth, it was the mother's injunction.

Second.—The points noted seem to establish the fact of euthanasia in cases of violent death, not only as to actual pain inflicted by the injury, but as to the anticipation of the horrible event.

Third.—The testimony of the individual upon the circumstances leading to his accident is to be taken with a certain amount of reserve. In case fourth the engineer of the train has of course declared that he did not fail to make the signals.—*Am. Practitioner.*

AMERICAN APPLES IN EUROPE.

By E. R. BILLINGS.

A GENERATION of fruit growers have passed away since the first shipment of apples from this country to Europe. Two varieties only were exported, the Esopus Spitzenburg and the Green Newtown pippin, the latter held being the finest sort grown in America. From that time until now shipments have been made from time to time, but not to any very great extent until 1872, when thousands of barrels of our finer sorts were shipped to Great Britain and other European countries. Last year upwards of 200,000 barrels were exported abroad, the fine quality of most of the fruit establishing at once the reputation of American apples for all time we hope. England, however, is noted for her fine apples, and Devonshire and Kent have produced for years excellent fruit, as well as pure cider of remarkable flavor and strength. But this is not the trouble, since quality is not the question of issue concerning the exportation of our products abroad. The cheapness of our exports is so astonishingly low while the quality is so fine, that not only our fruit crop is in active demand, but all of our great cereal and textual products.

The Newtown pippin pleased the palate of John Bull, while it proved to be the finest shipping apple this country has yet produced. This variety is grown in France, but their greatest pomologist, Andre Leroy, says that "it lacks the fine apple flavor common to it when grown in America." Next in the list of American apples that attracted attention in the Old World, and especially in Great Britain, was the Roxbury russet, a very late keeper, being in condition for the table so late in the season as July. Since then the Baldwin has come into very general favor abroad, and still later the King of Tompkins County, one of the largest and finest of our winter apples. The great size of this fruit has called out more or less comment from the agricultural press of Great Britain, while the patrons of Covent Garden market, London, have been delighted with its remarkable qualities. A curious feature of the export trade in apples consists in the fact that our English cousins prefer red apples to those of other colors, hence more red apples are exported than other colored fruit. Both English and American mer-chants handle the fruit on its arrival, all of which is auctioned off, as many as 14,000 barrels having been sold at a single day's sale. Thus far, the Newtown pippin and Lady apple have brought the highest prices, both of these sorts having sold last season at from $8 to $12 per barrel.

Not only have New York State, Ohio, and Michigan apples been exported, but also thousands of New England apples. So far this year New Hampshire and Vermont have been the principal New England States that have had a surplus for shipment; in the other States, excepting Maine, perhaps, the crop has been quite small. A well-known fruit grower on the Hudson River shipped his entire crop to Glasgow, making the shipment direct and not through other parties, and received much better prices than if sold to parties here for the use of American consumers of the fruit. Since the demand is for large apples and those that are red in color, it will be well for our fruit growers to bear this fact in mind when ordering trees, as well as shippers when making purchases. As a rule the poorer grades of apples do not command very remunerative prices, and some sorts sold last season at only a loss to the shippers. Fine fruit, however, sells readily, and both russets and R. I. Greenings command an advance of from $1.45 to $2 in English markets above prices here. It may be asked why are not apples exported from the North of Europe to Great Britain, since Russia and Sweden are noted for their apples, the great beauty of which has caused their introduction into this country, especially some of the finer summer sorts. The answer is easy. All Europe, and Great Britain especially, prefer to trade with the Great Republic, since we are at peace with all the world, and rival other nations in almost every product of the mineral and vegetable kind.—*Amer. Manufacturer.*

MANNA PRODUCTION IN ITALY.[*]

THE planting of Fraxinus trees in Italy yields pecuniarily a good return without any great trouble or cost being incurred. The best trees for planting are *Fraxinus ornus, L.,* and *F. excelsior, L.* The former species has been artificially introduced into Sicily and Calabria, though both species occur there growing wild.

When the tree has attained an age of eight to ten years it is used in the production of manna. For this purpose a horizontal incision is made in the bark with a sharp garden knife, equal to about one-fifth of the entire breadth. In doing this the following points are observed. In the first year the incisions are made upon the side of the tree toward which it inclines (the Fraxinus scarcely ever grows straight), and they always progress from below upward. The first incision is made at the base of the tree, and then one incision over another at intervals of one centimeter until the ramification of the branches is reached. The incisions are then made on the opposite side, commencing at the base of the tree as before. From the beginning of July to the end of September an incision is made daily in each tree.

The manna is collected during nine years, when the tree becomes exhausted and incapable of production. For this reason during the ninth year incisions are made simultaneously on both sides of the tree in order to use it up completely. The tree is now cut down, leaving only a single shoot, which at the end of four or five years is capable of production.

The juice, which flows only from the incisions, is at first brownish, and has a bitterish taste; but after some hours in contact with air it becomes solid, whitish, and sweet, forming long pipes or small stalactites. But frequently the juice is very fluid, and it then runs down, forming a kind of long plaster that adheres to the bark, while a portion drops to the ground, where it is collected upon leaves of *Ficus indica.*

The manna is collected once in the week, and only in fine weather; if rain falls the gathering is hastened. Rain and dew interfere with the profits. A man provided with two vessels goes round to the trees, collects the pipes and scrapes off the smooth mass lying on the surface, putting each sort into a different vessel, as in commerce they have a very different value. The first sort is the "manna canellata," the second, "manna in sorts." After the collection both sorts are spread out in the sun to dry a little, and then sold.

The gross returns from a hectare of land is on the average 850·35 Italian francs, viz., manna canellata, 6 kilos at 22·10 = 132·69; manna in sorts, 94 kilos at 7·50 = 705; wood cut down, 12·75. Total, 850·35 francs.

NEW USE FOR HEMP.

LEXINGTON (Ky.) *Gazette:* Four of the leading manufacturers of wire self-binders used in the year 1879, 9,000 tons of wire for binding grain, and they are now pretty well satisfied that twine will be substituted for wire. It is cheaper and has not the objections which millers urge against wire. If twine is used, these four manufacturers of self-binders will require 5,000 tons of twine, which will take 10,000 tons of rough hemp to make. A pound of wire is 300 feet long, while a pound of twine of the same size used is 800 feet, so at double the cost the twine is cheaper, besides being preferable in many respects. If four self-binding firms will use 5,000 tons of twine, it is safe to say that 50,000 tons will be required for all the self-binders made, and this may require 100,000 tons of rough hemp in a few years. As the entire crop of hemp grown in Kentucky last year is estimated by those best able to judge at not more than 8,000 tons, unless there is a vast increase in the area sown, it will leave the crop very much short of the demand. The manufacturers of self binders will be slow to change from wire to twine until they are assured of an ample supply of the latter, and this cannot be had until there is a large increase in the production of hemp. We think that it would be safe for our farmers to put in more hemp, with a reasonable prospect for a demand for all they can raise, but not at extreme prices, for the self-binder manufacturers will not give up the use of wire if they are to be mulcted too heavily in the price of twine; beside jute and sisal can be substituted for hemp in the manufacture of twine of sufficient strength to bind the grain. But hemp will make the best binding, and will be universally used if it can be had at a fair price.

This demand for twine opens a wide field for the farmers of Kentucky and the thousands of negroes who still linger among us and seem indisposed to emigrate. It is a kind of work they are used to and greatly prefer to all other species of farm labor. Iron took away from Kentucky farmers the raising of hemp for making rope for cotton bales, and they are about to recover more than they have lost in furnishing hemp for the twine used in the vast grain fields of the country. Every year will but add to this demand, and in a few years Kentucky will more than recover its ancient hemp industry. Twine and bagging factories will be rebuilt, for what hemp will not do for twine will make most excellent bagging, and we will present that most anomalous of all conditions—of a people who have recovered a lost industry after it had been taken from us for a quarter of a century. Instead of looking only to the South for a market as in the old time, we will send our product into every State, and will find in the vast grain fields of the North and West our largest and best customers. Our hemp lands will recover their former increased value, and an era of prosperity opens before our farmers such as has not been presented in a decade. What if the cheap lands of Texas and the West do furnish beef cattle at a lower price than we can afford them, they cannot produce hemp nor the finest specimens of breeding animals, and in those lines of industry we are practically without competition. We think our farmers may rejoice at the promise of a brilliant future, and such as has not opened to them since the first settlement of the country.

TWO VALUABLE INSECTICIDES.

LONDON PURPLE.[*]

THIS powder is obtained in the following manner in the manufacture of aniline dyes. Crude coal oil is distilled to produce benzole. This is mixed with nitric acid and forms nitrobenzole. Iron filings are then used to produce nascent hydrogen with the excess of nitric acid in the benzole. When distilled, aniline results; to this arsenic acid, to give an atom of oxygen which produces rose aniline, and quick-lime are added to absorb the arsenic. The residuum which is obtained by filtration or settling is what has been denominated "London Purple," the sediment being dried, powdered, and finely bolted. The powder is, therefore, composed of lime and arsenious acid, with about 25 per cent. of carbonaceous matter which surrounds every atom. Experiments which I made with it in 1878 impressed me favorably with those use as an insecticide, and its use on the Colorado potato beetle by Professors Budd and Bessey, of the Iowa Agricultural College, proved highly satisfactory. I was, therefore, quite anxious to test its effect on the cotton worm in the field on a large scale, and in the winter of 1878-79 induced the manufacturers to send a large quantity for this purpose to the Department of Agriculture. The analysis[†] made of it by Professor Collier, the chemist of the department, showed it to contain:

	Per cent.
Rose aniline	12·46
Arsenic acid	43·65
Lime	21·82
Insoluble residue	14·57
Iron oxide	1·16
Water	2·27
Loss	4·07
	100·00

Through the liberality of the manufacturers, Messrs. Hemingway & Co., a number of barrels of this powder were placed at my disposal the past season, and distributed to various observers and agents in Georgia, Alabama, and Texas. Early in the spring Mr. A. R. Whitney, of Franklin Grove, Illinois, found it to be a perfect antidote to the canker-worms which had not been prevented from ascending his apple trees, and the experiments of those whom I had intrusted to make them on the cotton worm, as well as those made under my own supervision, all showed that its effects are fully equal to those of Paris green. Like the latter it kills the worms quickly and does not injure the plants, if not applied in too great a quantity. Farther, it also colors the ingredients so as to prevent their being mistaken for harmless material. Finally, its cheap price removes the temptation to adulterate the poison, as every adulteration would prove more expensive than the genuine article. It is even superior to Paris green, as, owing to its more finely powdered condition, it can be more thoroughly mixed with other ingredients and used in smaller proportion. Experiments on a large scale have been made with the dry application at the rate of 2 lb. to 18 lb. of diluents, also at the rates of 1, ½, ¼, and ⅛ lb. to 18 of the diluents. The last proved only partially effectual, and in no case were the plants injured or the leaves even burned. In all but the last case the worms were effectually killed, but as the mixture, at the rate of ¼ lb. was applied with greater care and regularity than is generally had on a large scale, and also in very dry weather, the proportion of ¼ lb. to 18 of the diluents is most to be recommended. All higher proportions are simply waste of the material.

Like Paris green, it is not soluble,[‡] but is much easier kept suspended in water than the former. If applied in this way some care has to be taken in stirring it in the water, as it has a tendency to form lumps, owing to its finely powdered condition. Experiments on a large scale with this material diluted in water gave the following results: When used in the same proportion as Paris green, namely, 1 lb. of the poison to about 40 gallons of water, one experimenter reports that the leaves were slightly crisped, while four others report a perfect success, and no injury whatever to the plant. Experiments by myself and Mr. Schwarz showed that when applied in the proportion mentioned and thoroughly stirred up in the water the leaves were partly crisped, though by no means so much as by arsenic, even when applied in weaker solution. When used in smaller proportion, or at the rate of ¾ or ½ lb. to forty gallons of water, it did not burn the leaves and still proved effectual in destroying the worms. Repeated experiments on a smaller scale confirmed these results obtained on large fields, and also showed that the proportion may be still farther reduced, and when applied with great care and in very dry weather ¼ lb. to 40 gallons will kill. Still farther reduction in the proportion of the powder used gave negative results. I would, therefore, recommend the use of ½ lb. of this powder to from 50 to 55 gallons of water as the proportion most likely to give general satisfaction by effectually destroying the worms without injuring the plants.

All that has been said under the head of Paris green as to the desirability of adding a small quantity of flour or other substance to give adhesiveness to the liquid will hold equally true of London purple, but the latter has in many respects a great advantage over the former, especially in its greater cheapness, being a mere refuse which, from its poisonous nature, was a drug to the manufacturers and had to be got-

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[*] From advance sheets of Bulletin No. 3 of the U. S. Entomological Commission, by C. V. Riley.

[†] Ordinarily the rose aniline has mixed with it a little ulmic acid, and an increase of 2 per cent. of arsenic acid.

[‡] The manufacturers can render about 13 per cent. of it soluble if desired.

* Paper by J. Janssen, of Florence, in the "Agricoltura meridionale."

ten rid of by being dumped long distances out at sea. This substance can be put upon the market at the bare cost of transportation. It can be sold in New York at the low rate of 6 cents per lb., and there is no reason why it should not be obtained at any of the large shipping points in the South at figures ranging between 7 and 10 cents a pound. This means virtually that the cost of destroying the worms by this powder is reduced to such a minimum as to depend mainly on the labor and the other ingredients or diluents employed; in other words, that, while the planters, as heretofore, were obliged to pay as much as $1 for the first cost of the active poison needed for one acre, and never less than 15 cents, he may now obtain it for from 3 to 5 cents.

London purple has this farther advantage over other arsenical compounds hitherto employed: Its finely pulverized condition seems to give it such penetrating power that, when used in liquid, it tints the leaves so that cotton treated with it is readily distinguished at a distance, the general effect being quite marked as compared with any of the other poisons similarly supplied. It seems also to be more effectually absorbed into the substance of the leaf, and is therefore more persistent. At the same time experience shows that it does not injure the squares any more than Paris green.

PYRETHRUM POWDER.

The insecticide and insectifuge qualities of the dried and finely powdered flowerheads of different species of *pyrethrum*, and the harmlessness of the powder to man, to other animals, and to plants, have long since been known. Used against various household pests, under the names "Persian insect powder" or "Dalmatian insect powder," it has hitherto been put up in small bottles or packages and sold at such high prices as to preclude the idea of using it on a large scale in the field. The so-called Persian powder is made from the flowers of *Pyrethrum carneum* and *P. roseum*, while that from *P. cinerariæfolium*, a native of Dalmatia, Herzegovina, and Montenegro, is more generally known as Dalmatian powder. Some interesting experiments made during the past year on different insects by Mr. William Saunders, of London, Ontario, show that the use of this powder may be satisfactorily extended beyond the household, while a series which I made in the summer of 1878, with the same powder on the cotton worm, showed it to have striking destructive powers, the slightest puff of the powder causing certain death and the almost instant dropping of the worm from the plant. Repeated on a still more extensive scale the present year at Columbus, Tex., the powder proved equally satisfactory in the field.

Here, then, we have a remedy far exceeding any other so far known in efficacy and harmlessness to man and plant, and the only question in my mind has been to reduce its cost. There was some hope of doing this by ascertaining the destructive principle, and it is to Prof. E. W. Hilgard, of the University of California, that we owe the first accurate determination of the same. The following extract from a letter received from Professor Hilgard last September indicates the results of some of his experiments:

DEAR SIR: Yours of 22d is to hand. I have had Milco's product in hand for some time, and have tried it on various bugs both in powder and infusion. To understand the best manner of using it in each case, it must be kept in mind:
1. That the active substance is a volatile oil.
2. That said oil, under the influence of air, not only volatilizes, but is also oxidized, and thereby converted into an inert resin.

It follows from 1, that the pyrethrum is at a disadvantage when used in the shape of powder in the open air, especially when the wind blows; from 2, that it is of the greatest importance that the substance should be fresh, or should have been kept tightly packed, for the same reason that hops must be similarly treated.

Hence I find that Milco's fresh powder is of greater efficacy than the best imported, although some of the latter contains twice as much matter soluble in ether; but the extract from the "buhach" is a clear greenish oil, while that from imported powder, and especially that from "Lyon's magnetic"—ground up refuse, stems, etc., as I take it—is dark and thickish, or almost dry and crumbly.

Like all volatile oils, the essence of pyrethrum is soluble in water to some extent, and the tea from the flowers, and to a less extent that from the flower stems and leaves, is a valuable and convenient insecticide for use in the open air, provided that it is used at times when it will not evaporate too rapidly, and that it is applied in the shape of spray, whose globules will reach the insect despite of its water shedding surfaces, hairs, etc. Thus applied, I find that it will even penetrate the armor of the red scale bug—or rather, perhaps, get under it—so that the bug falls off dead in a day or two. The hairy aphides are the most troublesome, and require a strong tea of the flowers, atomized. The diluted alcoholic solution can, of course, be made as strong as you please, and will kill anything entomological.

Some persons have tried the decoction, and have of course failed, as the oil is dissipated by boiling.

My own experiments and those of Professor Hilgard were made with the powder from plants grown in California by Mr. G. N. Milco, of Stockton, and this powder, when used fresh, I have found to be more powerful than the imported kinds.

Mr. Milco, a native of Dalmatia, has been cultivating the *P. cinerariæfolium* in California in constantly increasing area for the past three years, and deserves great credit for his efforts in introducing it. The California product is put upon the market in neat bottles and packages under the name of "Buhach," and I am under obligations to Mr. Milco for the liberal supply which he has placed at my disposal free of cost, wherewith to carry on my experiments. Before considering the cost of using this insecticide in the cotton field it will be well to summarize the results of these experiments.

Pure pyrethrum powder, mixed with a small quantity of finely powdered rosin, was applied to the under side of the leaves by means of a small pair of bellows. Taking advantage of the direction of the wind and using the bellows freely, all the upper leaves of the plants were found to be well powdered, and consequently almost all the worms upon these leaves received at least some particles. The smaller worms died in convulsions in from 10 to 30 minutes, according to their size and to the quantity of powder they had received. Larger worms soon became uneasy, and finally fell to the ground, where they invariably died in from 5 to 24 hours.

Every attempt to restock with worms a freshly powdered plant failed. They evidently do not like the smell of the powder, and throw themselves from the leaves until they either fall to the ground or reach a leaf which has not been powdered.

Diluted with flour in varying proportions from one part of each up to one part of pyrethrum and ten of flour, it produced equally good results as when pure. Mixed with 16 parts of flour, it proved at first insufficient, but upon being kept in a tight glass jar for two weeks, it evidently gained in power, for it then proved almost as effectual as the stronger mixtures. The powder can be successfully sifted on the plants during cloudy days or during the evening when the worms are on the upper side of the leaves. On sunny days, or when the worms are just hatched, it is more necessary to apply it to the under side of the leaves, as it acts only when coming in actual contact with the worms.

A strong decoction of the powder applied to the leaves produced no effect; nor did the worms appear to suffer from eating leaves thoroughly soaked with this decoction.

An alcoholic extract of the powder, diluted with water at the rate of 1 part of the extract to 15 of water, and sprayed on the leaves, kills the worms that have come in contact with the solution in a few minutes. The mixture in the proportion of 1 part of the extract to 20 parts of water was equally efficacious, and even at the rate of 1 to 40 it killed two-thirds of the worms upon which it was sprayed in 15 or 20 minutes, and the remainder were subsequently disabled. In still weaker solution, or at the rate of 1 to 50, it loses in efficacy, but still kills some of the worms and disables others. I confidently recommend, therefore, the alcoholic extract of pyrethrum, diluted at the rate of 1 part of the extract to 40 parts of water, and sprayed upon the plants, as an effectual remedy against the worm.

The extract is easily obtained by taking a flask fitted with a cork and a long and vertical glass tube. Into this flask the alcohol and pyrethrum is introduced and heated over a steam tank or other moderate heat. The distillate, condensing in the vertical tube, runs back, and, at the end of an hour or two the alcohol may be drained off and the extract is ready for use.

Let us now briefly consider the approximate cost of using this material at present figures. The powder is now selling in California at wholesale, in 8 lb. packages, at $1.25 per lb.; but from facts kindly communicated by Mr. Milco, it appears that he has raised as much as 647 lb. to the acre, and that the cost of production, milling, etc., on a large scale, need not exceed 6 to 7 cents per lb., because in the experiments attending the introduction of the plant many obstacles and expenses incident to new enterprises have had to be met. The plant is wonderfully free from insect enemies, and blooms all through the summer, and there seems no good reason why it should not grow in most of the Southern States.

Carefully estimating from the results of experiments made, it will require about one and three-quarter pounds of the pyrethrum powder to go over an acre of cotton at medium height; in other words, that quantity of pyrethrum to 20 lb. of flour or other diluents will answer the purpose. Such being the case, the question as to whether the pyrethrum can be used as a substitute for Paris green, London purple, and other arsenical powders resolves itself in one of relative market price, and if Mr. Milco's estimates are warranted—and no one in the country is better able to state the facts or give the figures on the subject—the pyrethrum may be produced as cheaply as even London purple. It is a question which future experience alone can determine, but that the prospects are encouraging there can be no question, and it is highly probable that the planter in the future will make it a rule to grow a patch or a few rows of this most useful plant as a ready means wherewith to protect his crop from the worm whenever the occasion for so doing presents itself.

So far as experiments have been made there would seem to be a decided advantage in point of economy in the use of the crude powder, since, in the ordinary methods of spraying, 40 gallons of liquid are required for an acre, and to produce this amount of diluted extract of pyrethrum at the above figures would require about six pounds of powder. This diluted extract has the advantage, however, over every other liquid so far used that it contains no solid and obstructing particles. It may, therefore, doubtless be used in a much finer spray than any of the other poisons.

THE CHINCH BUG.*

AMOUNT OF INJURY IT CAUSES.

THE Chinch bug (*Blissus leucopterus*, Say) is unquestionably one of the most formidable insect pests with which the farmers within the wheat producing area of the United States have to contend. Although not exceeding a grain of wheat in size, rather slow motioned and possessing no other weapon of destruction than its tiny slender beak, yet the species is enabled to make up by number for the lack of individual capacity for destruction.

The locusts of the West are the only creatures of this class "which exist within the bounds of our national domain whose multiplication causes more sweeping destruction than does that of this diminutive and seemingly insignificant insect." In the territory east of the Mississippi it is without a rival.

Mr. Walsh estimated the loss from the ravages of this insect in Illinois alone in 1850 at 4,000,000 dollars, an average of $4.70 to every man, woman, and child then living in the State.

Dr. Shimer says that it "attained the maximum of its development in the summer of 1864, in the extensive wheat and corn fields of the valley of the Mississippi, and in that single year three-fourths of the wheat and one-half of the corn crop were destroyed throughout many extensive districts, comprising almost the entire Northwest, with an estimated loss of more than 100,000,000 dollars in the currency that then prevailed."

Mr. Thomas, in his second report, as State Entomologist of Illinois, remarks as follows in reference to the loss occasioned by them in 1871:

"I find no complaints of damage recorded in 1870, but as the summer was dry over a large area, and they appeared in immense numbers in 1871, it is more than probable that they began to increase in the latter part of the season."

As Dr. LeBaron has noticed somewhat fully in his second report their operations in 1871, it would be unnecessary for me to do more than advert to it, were it not for the fact that this second report does not appear to have been generally distributed and is rarely seen. The following quotation will suffice to show the extent and severity of this visitation:

"Some idea of the loss caused by the depredations of this insect in this and neighboring States may be realized when we learn that over a belt of territory one hundred miles wide, commencing in the western part of Indiana, and

*From advance sheets of Bulletin No. 5, of the U. S. Entomological Commission, by Cyrus Thomas.

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extending more than 400 miles west, embracing an area of more than forty thousand square miles, the great staple of spring wheat was reduced to not more than a quarter of an average crop, and in many places wholly destroyed; and that over the same territory barley was less than half a crop, and oats not more than three-quarters of their usual amount.

"The center of this belt appears to have been a little north of the center of the State, being about on a line with the junction of Iowa and Missouri, and taking in a corresponding part of southern Iowa and Nebraska, and of northern Missouri and Kansas. South of this belt winter wheat takes the place of spring wheat and barley, and the chinch bugs, though present in considerable numbers, ceased to commit any very serious damage. North of this belt, also, notwithstanding that spring wheat constitutes a leading crop, the bugs became gradually less numerous, and a tolerable crop of this grain was harvested. And yet all through northern Illinois and the southern parts of Wisconsin, these insects were numerous enough to damage the crop to some extent, and to excite the most serious apprehensions for the succeeding year.

"In order to obtain as correct an idea as possible of the amount of loss sustained by the agriculturist from the depredations of this insect the past year (1871), both in this and the Northwestern States, I have made the following calculations based upon the statistics of the Department of Agriculture, with a reasonable estimate of the proportional damage caused by this insect to those crops upon which they depredate. All such calculations must necessarily be only approximately correct, and very loose and extravagant conjectures have sometimes been indulged in upon the loss caused by chinch bugs in former seasons of their prevalence. It has been my intention to keep within reasonable bounds, and, by giving the figures in the case, I give others the opportunity to review my estimates.

"Taking the returns of the Department of Agriculture, for the years 1869 and 1870, for our guide, we may assume the present annual yield of wheat in the State of Illinois to be 30,000,000 of bushels, of oats 40,000,000, and of barley 3,000,000.

"The area seriously ravaged by these insects comprised, as we have above stated, about the middle third of the State. This section would bear its full proportional third of the wheat and oats, and at least one-half of the barley raised in the whole State. This would give as the product of that part of the State ravaged by chinch bugs 10,000,000 bushels of wheat, upwards of 3,300,000 bushels of oats, and 1,000,000 bushels of barley. The proportion of these crops destroyed by chinch bugs we have put at three-quarters of the wheat, one-half of the barley, and one-quarter of the oats. This will give as the amounts actually destroyed by these insects, 7,500,000 bushels of wheat, 500,000 bushels of barley, and in round numbers, 3,300,000 bushels of oats.

"If we make a cash estimate of this loss, by putting the price of wheat at one dollar a bushel, barley at fifty cents, and oats at twenty-five cents, we shall have an aggregate loss of upwards of eight and a half millions of dollars in the central third of the State of Illinois.

"In this estimate we have made no account of the injury done to corn throughout the State, nor of the damage to small grains north of the central belt. Here the calculation becomes more indefinite, but I believe it will be generally admitted to be a low estimate if we add, for this purpose, one-quarter part to the above aggregate of loss. This will make the total loss caused by chinch bugs, in the State of Illinois, in the year 1871, upwards of ten and a half millions of dollars. If we assume an equal amount of loss for the two States of Iowa and Missouri combined, and another equal amount for the four States of Indiana, Kansas, Nebraska, and Wisconsin, we shall have a total loss in one year, in the Northwestern States, of upwards of 30,000,000 of dollars, from this one species of insect."

The loss in 1874 was probably equal to them in 1864.

Prof. Riley made a careful estimate by counties of the loss in Missouri, which he found to aggregate the large sum of $19,000,000. I made careful estimates of the loss on corn alone in Illinois by this insect in 1874. These estimates were based on different data so as to form checks the one upon the other, and the loss by drought was eliminated. The results showed a loss of about 20,000,000 of dollars on this single cereal. The entire loss to the State that year by the operations of this pernicious insect were not less than 30,000,000 dollars, $11.50 to each inhabitant.

If the loss in the two States, Missouri and Illinois, amounted to nearly $50,000,000, it is not probable that the entire loss to the nation by this diminutive insect in 1874 fell any short of 100,000,000 dollars.

As the species appears to have a maximum of development about every five years, the foregoing estimates render it probable that the annual loss to the nation by its operations averages $20,000,000.

RAVAGES OF PHYLLOXERA.

THE phylloxera has, up to the close of last year, extended over more than 1,600,000 acres in France, and utterly ruined the vines in 700,000 of them. The appearance of the insect is even reported in the Medoc, the most famous vine growing section of France, and Chateau Lafitte, for which Baron Charles Rothschild paid $830,000 two years ago, is nearly ruined. At this rate, it is expected that the whole district will be infected before the end of next year. Sulphuret of carbon is the most favored remedy, though deep trenching and manuring, with an application of turpentine and powdered rosin to the roots, is said to be a cheaper and equally effective remedy. Some vine growers are planting American stocks, thinking them less liable to attack.—*Land and Home.*

MILK BEER.

THIS new article of diet, said to be largely used in France for medical purposes, has lately been patented in this country by Edward Kokosinski, of Paris.

"The object of my invention," he says in his patent, "is to manufacture a beer which will possess special nutritive and hygienic qualities; and this object I attain by using whey in place of the water usually used in the manufacture of ordinary beer, as more fully described hereinafter.

"To make my improved beer, or milk beer, I use the following proportion of ingredients, namely, thirty-three kilogrammes of malt, one hundred and fifty liters of whey, and sixty grammes of hops, preferably Bohemian hops.

"The whey should be freshly prepared, and be free from lactic fermentation and lactic acid.

"In brewing, a thick wort is used, and the fermentation is conducted at a low temperature, the steps of the brewing process being otherwise the same as in brewing ordinary

beer. A brewing of the above quantities of materials will produce about a hectoliter of my improved beer.

"The use of whey in place of the water in ordinary beer results in imparting to the beer a greater quantity of albuminous matter and salts, which the milk contains, and which are identical with the salts of the blood, and thus renders the beer very nutritious.

"If desired, medicines such as quinine, tar, iron, etc., may be incorporated in the milk beer during its manufacture."

RAILROAD SHAKES.

By S. W. ROBINSON, Department of Physical and Mechanical Engineers, Ohio State University.

THIS term may perhaps justly be applied to a sort of railroad malady, which so afflicts some roads that passengers riding over them are sure to suffer in consequence, without respect of person; and the remedy is not found in bolus or pellet. Indeed to become sea sick on a railway train is of somewhat frequent occurrence, so severe are the storms of *railway shakes*.

When an engineer stakes out a railroad, great care is exercised in the "alignment;" and the rails must be adjusted with nicety to it. Deviations would look bad, and quite small ones could be detected by the eye alone. It is therefore quite essential that this be carefully attended to, though another alignment of even greater influence upon the train, but whose error is less easily detected by the unaided eye, is almost entirely ignored; and at best left to the mercy of the section men.

A person standing upon a straight railway track could, by sighting, detect an error of ¼ inch to the 100 ft. in straightness. Deviations vertically could be about as easily detected if the eye were to take a favorable position for examination. But the fact that nobody is likely to take the trouble to thus inspect the track is, it seems, taken as license for admitting errors to the extent of an inch or more to the 100 ft. There is many a track which, if the horizontal and vertical alignments were interchanged, would become astonishing objects to behold. No railroad man would approve such a track, and yet the effect of it, in shaking up a train, would be far less than before the interchange. A few considerations will suffice to indicate this.

First. Suppose a car to follow a track full of such horizontal inequalities, the vertical errors being nil. The whole car would be jogged about to the same extent; the top as much as the bottom. But the cars would probably not follow the track exactly, some of the short turns being dodged over, and to this extent the jostling would be modified. This would be still further relieved in trains where the couplers form comparatively rigid connectors, as adopted now on many roads.

For the sake of the comparison, suppose next, that the track errors are as usual, viz., vertical. Now, first, if both rails rise and fall exactly alike or together, the car would rise and fall to the same extent; these displacements being the same as the lateral movements in the previous case, if the car followed the rails exactly. But because gravity compels the car to follow the vertical crooks exactly, and as it would hardly follow the horizontal ones, the passengers would suffer most from the errors in vertical. But in the second place the two tracks will not exactly duplicate each other's crookedness, one rail perhaps being lowest where the other is highest. Such a condition of track will of course greatly aggravate the jostling action; the car being tilted first to one side and then to the other. To get a little idea of this, suppose one rail to be exactly straight, and the other in error vertically. Then, at the point of a depression, for instance, of one inch, the tilt or rock of the car, with the straight rail the axis of motion, will be one inch at every point in the arc of a circle, or rather surface of a cylinder struck through the car, about the straight rail as center or axis, the radius being the gauge of track. If the latter distance be 4' 8½", the passengers will be beyond this circle, and hence their displacement will be greater in extent than the 1" error in the one rail. Now if the two rails are in error, the possible disturbance will be about doubled, the effect of which is anything but pleasant.

Section foremen, who largely control this matter, should therefore be selected with care as possessing the skill necessary for securing the desired adjustment of track.

In the preceding, the terms horizontal and vertical, as applied to alignment, are used in the same sense as when applied by engineers to curves, as horizontal or vertical curves. Horizontal alignment has reference to the line, as projected upon a horizontal plane, etc.

Perhaps too little credit is given in the above to the civil engineer, for the relative portions of attention devoted to the two kinds of alignment. The leveling instrument is one whose precision falls not very far short of that of the transit, and hence the center line, as given to the construction masters, may be faultless in every respect. But as this line consists of points only, and 100 feet apart, or possibly in some cases less, it follows that the intermediate points may, without any wit or allowance of the engineer, be subject to considerable deviations, especially as this is mostly left in great measure to no better instrument than the naked eye. Right here is where the failure in alignment above complained of begins. A new road may evidently be thus subject at fault. And the more the track is doctored in after years for setting, treated with fresh ballast, etc., the more it may get into error. As this almost reconstruction of the track is usually placed in charge of men of no high degree of mechanical judgment or ocular precision, it is no great wonder that some roads ride very badly. It is very likely that the greater portion of the men who have this trimming of the track in direct charge, have no appreciation of any importance as attaching to the vertical alignment, each rail line being simply kept straight as viewed from above. But as the latter adjustment should receive especial attention as compared with the other, as previously pointed out, it seems to follow that the undenominated rule in practical force for the adjustment of tracks is about thus: *the attention given to each element of adjustment of railway lines is inversely as its importance.*

The above considerations apply to straight tracks. As regards curves it is easily seen that greater difficulty will be encountered in attempting to secure perfect adjustment of rails. One fact in connection with the elevation of the outer rail should be noticed here. Doubtless many an observing traveler has noticed a considerable side thrust of car at striking the initial points of a curve. Also the termination of the curve is noticeable. If, however, the speed of train and elevation of outer rail be adapted to each other, it would seem that this should not be. The point to be noticed here is that in practice the center line of curve is usually made tangent to the center line of the adjacent straight track. This should not be so, because evidently the car should be

so carried around the curve as to cause the least disturbance to its mass. To this end it appears that the center of gravity of a car should be so carried around the curve as to describe a path which is tangent to the adjacent straight branches. This is not the case in practice, the curved part of path being inside of its true position. To secure this tangency which is necessary for the best conditions, it will be necessary to set the rails outward, at curves, to an extent determined with due regard to the difference of level of rails, and height of center of gravity of car above road bed. Also one rail should be elevated, and the other depressed, instead of simply elevating the outer rail.

It would seem that all these desirable qualities of a road could not be secured short of the aid of a sort of preparatory school for section bosses, in which they are to have their understandings sharpened as regards proper adjustment of rails to line, consequences of error, etc. The weight of responsibility placed upon them should be more dependent upon their success at the school. Certain simple instruments should be introduced into rail line adjustment, and instruction in their use given at the school. For instance, to facilitate vertical adjustments, a simple mirror placed edge to rail, and at an angle of 45°, would enable the adjuster to sight along a line of rail by simply looking downward. An attendant can then be sent along to different points and note them for high or low. Another device should also constantly be in hand, which, by a level, will give the relative heights of the rails at opposite points. It could consist of a cross bar of gauge length, with a leg at each end, and a level swinging to different settings. In use, one leg is placed on each rail line, with level at the proper point for "straight" or "curve," etc. An instrument might also be devised, having a telescope or not, which could conveniently be so set as to lie in the line of a straight track, or swing in the plane of a curved track. Then, with a rod of a length equal the height of instrument above rail, one could detect inequalities in line of curve.

Finally, it might be stated, that as a matter of fact the riding quality of different roads varies greatly, some of which are already nearly faultless. This would indicate that if all the men who trim up tracks were equal to the best, the comfort of passengers would be greatly increased, accidents diminished, and discrimination between roads mostly disposed of.—*Van Nostrand's Magazine.*

EARLY SUGGESTIONS CONCERNING THE CASTING AND PRODUCTION OF HEAVY ORDNANCE.

AMONG the earliest suggestions on this subject were probably those of Mr. W. H. Ward, of Washington, author of the following, which was published in the SCIENTIFIC AMERICAN of January 1, 1846, which we now republish:

[From the SCIENTIFIC AMERICAN, Jan. 1, 1846.]

The present affairs of our nation with foreign powers will no doubt render the use of heavy ordnance indispensably necessary in the defense of our national rights. Permit me, therefore, to offer a few facts, as well as a few suggestions, on the subject of the manufacture of heavy ordnance, both wrought and cast; much capital having been invested and expended in this branch of our national defense, as well as some of the most valuable lives lost through the imperfections, either in the manufacture of heavy guns, or in the material used for that purpose. It will be found very advantageous to have cannon of large caliber for the purpose of throwing shells with as much accuracy as solid shot are from cannon, and thus enabling shells to do much execution; shells for this purpose being required ten or twelve inches in diameter. Long guns for this sized shot or shells are liable to burst on the first trial and not to stand the required proof generally used to test them. It is to the manufacture of large cast-iron cannon that I wish to call the attention of those concerned. In the first place, cannon of a large caliber are found to burst easier than those of a smaller caliber where the preparations are fully carried out; for instance, a nine-pounder cannon stood the test of 17 lb. of powder, six shot, and one wad (which filled it full), while many of the eight-inch, or 64-pounder cannon, burst with 20 lb. of powder and two shot, or 25 lb. of powder, one shot, and two wads; the latter containing more than three times the quantity of metal, and both guns being the same length. A 42-pounder gun will stand the test of 25 lb. of powder, two shot, and two wads; and the 13-inch or 256-pounder guns will scarcely bear the test of 25 lb. of powder and one shot; which goes to show that very large cannon are subject to a heavy strain besides the strain occasioned by proving them; and this strain is caused by casting the gun solid and boring it afterward. All metals will expand while heating and shrink while cooling; thus we see that the surface of cannon cannot shrink on account of their being cast solid. The outside is required to shrink much more than the center, which does not shrink at all, and the result is that the boring out a chamber in the piece thus cast, of ten or twelve inches in diameter, takes out all the metal that is subject to no strain at all, while the outside is subject to a strain of several thousand pounds; and this tendency to shrink acts in conjunction with the powder, which causes it to burst. To cast such a bulk of metal hollow, as is required for guns of this size, seems almost an impossibility. If we use sand for a core, and subject it to the heat of melted iron, it would melt to glass, and could not be bored or rimmed out. A clay core could not be suspended sufficient to keep its proper place; and even should it be so suspended and secured as not to move, it would be otherwise objectionable by not letting the steam or air escape, and the casting might be subject to air holes and not be solid; and another great objection is, that it would burn to brick as hard as flint or to cinders. I can conceive of only one way to cast heavy guns hollow, and that is by making a hollow pipe sufficiently strong to bear the test, and two inches less in diameter than the required diameter of the bore or chamber of the gun, and perforated full of small holes, and shut up at the bottom or lower end, while the other is left open. Around this pipe should be a coating of half or five-eighths of an inch in thickness of blacklead, well glazed on the outside; and said pipe should be some six or eight feet longer than the intended gun, for the purpose of securing and suspending it in the mould. When fully prepared for use it must be secured in the proper position in the mould, which stands perpendicular, and far enough from the bottom of the mould to leave sufficient strength of metal beyond the chamber of the gun for the breach after ramming. Cannon cast in this manner would have a full opportunity to shrink, leaving the metal subject to no strain whatever. They will cool more equally, and while cooling, will shrink and compress the blacklead, pressing it through the perforated holes in said pipe, which, being hollow, will also admit of all gas, air, etc., to escape, while the black-

lead will pass to the interior. The said pipe must of necessity be of wrought iron; and should it be found impossible to get the said pipe out by working, etc., it can be found out, which would be much better than to have a gun of the same weight, but of not more than half the strength. I find that a great mistake as to proper cannon augers, or rammers, prevails throughout all cannon foundries, viz.: it appears that in boring, one drill-pointed tool is first used, whereby the first hole is made when the gun is solid; this is very well, but it is the rimmers or finishers that I have reference to. Most machinists use four cutting joints. An odd number should be used, and placed at an angle of fifteen or twenty degrees; this will enable the auger or rimmer to work more freely. Let the original hole be any shape, only a little smaller, and you will have the bore of the gun as it should be, perfectly round and straight, without any difficulty whatever. As to the utility of wrought iron cannon and their manufacture, I will hereafter treat upon that subject, also the utility of percussion shells, etc.

Yours, etc.,

W. H. W.

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PATENTS.